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ZEBRA MUSSEL CHLORINATION BENTHIC SURVEY 1990

Report 91-81-K

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ABSTRACT

Chlorine was used for zebra mussel (*Dreissena polymorpha*) control at Ontario Hydro generating stations in 1990. The objective of the benthic survey was to determine, as a condition of the Certificates of Approval to discharge chlorine residues, whether the chlorine residues affected benthic communities in the generating station discharge plumes. Benthic samples were collected prior to and within approximately 2 weeks after chlorination at four affected generating stations, Darlington NGS and Lakeview, Lambton and Nanticoke TGS. Divers collected triplicate samples with an underwater air lift system at 3 reference and 3 discharge locations. Variations within the reference and discharge benthic communities at each of the 4 stations were not probably attributable to chlorine discharge. Instead, the variation was probably attributable to variances between reference and discharge sampling sites and sampling technique. The Asiatic clam (*Corbicula fluminea*) was present in low numbers in the Lambton TGS discharge.

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EXECUTIVE SUMMARY

ZEBRA MUSSEL CHLORINATION BENTHIC SURVEY 1990

R.W. Sheehan

Ontario Hydro was requested by the Ontario Ministry of the Environment (OMOE) to conduct discharge plume benthic surveys at generating stations utilizing chlorine for zebra mussel (*Dreissena polymorpha*) control. Conducting these benthic surveys was a condition of the OMOE Certificates of Approval for discharge of the chlorine residues.

The benthic communities were sampled at four Ontario Hydro generating stations (Darlington NGS, Lakeview TGS, Lambton TGS and Nanticoke TGS) which used chlorine in the zebra mussel control program. Sampling at Niagara River hydraulic generating facilities which used chlorine was not attempted due to diving safety concerns.

Benthic organisms were collected at similar reference and discharge sampling sites at each of these stations prior to (May) and after (December) chlorination. Divers collected the benthic samples using an underwater air lift collection system. Triplicate samples were collected at 3 reference and 3 discharge sites which had similar depth and substrate components whenever possible.

Darlington NGS

The density of benthic organisms was greatest at the Darlington NGS May reference sites. Benthic density decreased in December at both the reference and discharge sites with the majority of organisms being present in the discharge samples. The total species richness was also greatest in the reference samples during both sampling periods. The variation between the reference and discharge benthic communities was not significant and was probably not related to the discharge of chlorine residues.

Lakeview TGS

The majority of benthic organisms were present in the reference samples during both sampling periods at Lakeview TGS. The density

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and richness of the benthic communities increased at both sites in December. Benthic species richness was greater in the May discharge samples; however, the species richness was greater in the December reference samples. The density of organisms in the December discharge samples was significantly greater than in the May discharge samples. However, the December reference and discharge benthic densities were not significantly different. The variation in richness in the May and December discharge samples was not significant. Therefore, it is unlikely that discharged chlorine residues detrimentally affected the discharge benthic community.

Lambton TGS

The benthic community densities were highest at the Lambton TGS reference sites in both sampling periods. Similarly species richness was highest at the reference locations in both sampling periods. Benthic richness declined from May to December at the reference and discharge sampling locations; however, benthic densities increased at these locations during the same period. No significant variation was determined between the reference and discharge benthic densities in May or in December. Benthic richness was also not significantly different at both locations throughout the survey. These results indicated the discharge of chlorine residues probably did not affect the discharge benthic community.

Corbicula fluminea (Asiatic clam) was present in low numbers in the Lambton TGS discharge. These organisms can contribute to biofouling problems in water intake systems.

Nanticoke TGS

The greatest number of organisms at Nanticoke TGS were present in the May discharge samples. The majority of these organisms were zebra mussels. Benthic density decreased in December when the highest number of organisms were present in the reference samples. Benthic richness was highest in the reference site samples in May and December. The December discharge benthic density was not significantly different than the December reference or May discharge densities. The May and December discharge species richness values were also not significantly different. The variation within the benthic communities was therefore probably not related to chlorine residues in the discharge.

Variation within the reference and discharge benthic communities may have been related to differences in bottom water temperatures, substrate composition and sampling technique at the reference and discharge sampling sites.

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ZEBRA MUSSEL CHLORINATION BENTHIC SURVEY 1990

1. INTRODUCTION

Dreissena polymorpha (zebra mussel) continued to disperse and increase in abundance within the Great Lakes in 1990. This resulted in greater entrainment of and colonization by zebra mussel veligers at Ontario Hydro generating facilities. In order to control zebra mussel fouling within the generating facilities, the station service water systems were chemically treated with chlorine (sodium hypochlorite, NaOCl).

The use of chlorine to control zebra mussels at Ontario Hydro facilities was conditionally approved by the Ontario Ministry of the Environment (OMOE) in 1990. One condition of the Certificates of Approval, enabling each station to utilize their chlorination systems, required Ontario Hydro to conduct benthic surveys at each of the affected generating facilities. The objective of the benthic surveys was to determine whether or not the chlorine residues (0.01 mg/L) affected the benthic communities in the discharge plume.

The Environmental Protection Department (EPD), Central Production Services, requested Biological Research Section to perform the benthic surveys as designed by OMOE and EPD.

2. METHODS

The benthic survey experimental protocol followed procedures presented in the 1990 memorandum of agreement on benthic sampling, (P.M. Wiancko, EPD to OMOE). The benthic community species composition and abundance were sampled prior to and within approximately two weeks after chlorination at each of the affected facilities (Table 2.0-1). Sampling was not conducted at the affected Niagara River hydraulic generating facilities due to diver and personnel safety concerns. Six sampling sites were selected at

each facility; three in the area influenced by the plume and three reference sites outside of the plume influence (Figures 2.0-1 - 2.0-4). Triplicate samples were collected from each of the sampling locations. Each sampling location was identified by LORAN C coordinates and notable landmarks to permit postchlorination sampling in the same general area.

Similar substrates were selected for sampling at each of the generating facilities and at individual replicate sampling locations whenever possible (Appendix A). Hard surfaces were selected for sampling locations whenever possible. The divers did not manually disturb rocks in the sampling area. Replicate sites were also located at the same sampling depth whenever possible. Sampling depths ranged between 3 and 7 m except at Darlington NGS where the samples were collected at approximately 10 m. The 10 m depth was the minimum depth at the inshore end of the Darlington NGS diffuser.

Table 2.0-1

Zebra Mussel Chlorination
Benthos Sampling Dates 1990

	SAMPLING DATE	
LOCATION	PRECHLORINATION	POSTCHLORINATION
DARLINGTON	May 28	Dec 18
LAKEVIEW	May 25	Dec 6
LAMBTON	May 23	Dec 3, 4
NANTICOKE	May 15, 22	Dec 19

Benthic samples were collected with a diver operated air lift system (Figure 2.0-5). The divers positioned the metal boundary sample bucket (0.05 m^2 inside area) with the bottom edge gasket on the selected substrate. The area within the sample ring was then vacuumed with the air lift system. The depth and duration of sampling was dependent upon the substrate and diver visibility present at the sampling locations. Maximum substrate sampling depth was approximately 20 cm in loose substrate material. Greater amounts of material were vacuumed from the centre of the collection ring in loose substrates than from around the sides. This was due to the diameter of the air lift tube (7.5 cm) and the circular sample ring.

The air lift system was capable of vacuuming silt from underneath loose rocks and would lift rocks up to 10 cm diameter. The system removed the majority of attached algae but only a small percentage of attached mussels.

The prechlorination air lift samples were collected in 370 μm mesh

Nitex nylon bags positioned on the top of the air lift system. The nylon bags were replaced in the postchlorination sampling with PVC tubes with 370 μm metal mesh sides. The use of the sampling tubes increased the crew efficiency.

The sample bag/tube contents were sieved and cleaned prior to preservation in 5 - 10% formalin. The benthic samples were sorted and identified to genera or species level. Subsampling was undertaken for identification when large numbers of organisms were present. Unidentified species and life stage classification of genera/species (immature, pupa) were considered as separate groups for analysis purposes.

Statistical analysis was performed with notched box plots (Appendix B). Box plots permitted determination of differences in the population medians at about the 95% confidence level (Wilkinson, 1990). Significant differences could be inferred when the intervals around two population medians did not overlap. The benthos density box plots were derived from the number of organisms present at each of the replicate sampling sites (9 reference and 9 discharge sites/sampling period). The richness box plots were composed of the number of taxa present in the 3 reference and 3 discharge sampling locations during each sampling period.

3. RESULTS AND DISCUSSION

3.1 Darlington NGS

May Sampling

The zoobenthos results from the 9 reference and 9 discharge sampling sites are presented in Appendix C. These results are summarized in Appendix D.

The May Darlington NGS zoobenthic community consisted of 9 major taxonomic groups as presented in Table 3.1-1. All taxonomic groups were present in the discharge site samples, while only Decapoda was absent in the reference site samples. Diptera comprised the major taxonomic group in the May samples with 17 and 16 taxa present in the reference and discharge samples respectively. Mollusca, Oligochaeta and Acarina were the other major taxonomic groups.

The greatest number of organisms were present in the Oligochaeta group in both the reference and discharge samples. These organisms comprised 48.0 (reference) and 58.5% (discharge) of the total number of organisms. Diptera and Mollusca groups were also numerous in both the reference and discharge samples.

The number of organisms in the reference samples (n = 2 563) was greater than the number of discharge sample organisms (n= 1 791). The total number of organisms collected in the 3 reference samples ranged from 659 to 958 organisms ($\bar{x}$ = 854 organisms, Figure 3.1-1).

The number of organisms in the 3 discharge samples was lower ranging in number from 373 to 922 organisms ($\bar{X}$ = 597 organisms).

Forty-eight taxa were represented within the reference and discharge site samples (Figure 3.1-2). The number of taxa present in the reference samples was very similar ranging from 30 to 34 taxa per site representing a total of 44 taxa. The discharge sample species/group composition ranged from 25 to 29 taxa per sampling site representing a total of 39 taxa.

Table 3.1-1

Zoobenthic Community By Taxonomic Group
Darlington NGS, 1990

MAY

TAXONOMIC GROUP	REFERENCE NUMBER OF TAXA	REFERENCE #	REFERENCE %	DISCHARGE NUMBER OF TAXA	DISCHARGE #	DISCHARGE %
ACARINA	5	74	2.9	3	97	5.4
AMPHIPODA	3	149	5.8	3	83	4.6
DECAPODA	0	0	0.0	1	2	0.1
ISOPODA	1	219	8.5	1	100	5.6
DIPTERA	17	441	17.2	18	313	17.5
MOLLUSCA	8	367	14.3	6	147	8.2
TRICOPTERA	2	25	1.0	1	2	0.1
OLIGOCHAETA	6	1230	48.0	4	627	58.5
HIRUDINEA	2	58	2.3	2	8	0.7

DECEMBER

TAXONOMIC GROUP	REFERENCE NUMBER OF TAXA	REFERENCE #	REFERENCE %	DISCHARGE NUMBER OF TAXA	DISCHARGE #	DISCHARGE %
ACARINA	2	94	8.4	3	95	8.5
AMPHIPODA	2	131	11.6	3	76	6.8
DECAPODA	1	1	0.1	0	0	0.0
ISOPODA	2	69	6.2	2	58	5.2
DIPTERA	11	179	15.9	10	299	26.7
MOLLUSCA	6	10	0.9	4	11	1.0
TRICOPTERA	2	3	0.3	2	3	0.3
OLIGOCHAETA	7	627	55.9	5	656	58.5
HIRUDINEA	2	7	0.6	2	8	0.7

- number of organisms

Immature Tubificidae (Oligochaeta) were the predominant organisms present in both the reference (n = 1 137) and discharge (n = 990) samples. *Pisidium compressum* was the dominant Mollusca in both the reference and discharge samples while *Pisidium punctatum* was also prevalent in the reference samples. *Asellus intermedius* was the only Isopda species identified ranging in density from 100 organisms in the discharge samples to 219 organisms in the reference samples. The reference site Diptera population was represented primarily by the Chironomidae *Cladotanytarsus sp.* The dominant Chironomidae in the discharge population were *Dicrotendipes sp* and *Cladotanytarsus sp.* Acarina were represented primarily by *Hygrobetes sp* which were more numerous in the discharge samples than in the reference samples.

Dreissena polymorpha (zebra mussel) were present at each of the reference sampling locations. The numbers collected at each site were low ranging in number from 2 to 19 specimens. *Dreissena polymorpha* were not present in the discharge samples.

December Sampling

The December Darlington NGS zoobenthic community was comprised of 9 major taxonomic groups (Table 3.1-1). All taxonomic groups were represented in the reference samples while Decapoda was not present in the discharge samples. Diptera was the dominant taxonomic group in both the reference and discharge samples. Oligochaeta and Mollusca were the other major taxonomic groups. The majority of organisms present were Oligochaeta in both the reference (55.9%) and discharge (58.5%) samples. The remaining reference site organisms were primarily Diptera and Amphipoda while the other discharge site organisms were primarily Diptera and Acarina.

The number of organisms in the discharge samples (n = 1 206) slightly exceeded those in the reference samples (n = 1 121, Figure 3.1-1). The number of organisms in the 3 discharge samples ranged from 81 to 615 with a mean value of 402 organisms. The variation was similar in the discharge samples where the number of organisms ranged from 77 to 660 at the 3 sample locations ($\bar{x}$ = 373 organisms).

The number of taxa was slightly higher in the reference samples (n = 35) than in the discharge samples (n = 31, Figure 3.1-2). The mean number of taxa ranged from 21 (discharge samples) to 24 (reference samples) taxa.

Oligochaeta, represented primarily by immature Tubificidae, was the dominant taxa present in the December samples. The number of immature Tubificidae was very similar at both sampling locations. They composed 52.4% of the reference sample and 47.8% of the discharge sample. Diptera were more prevalent in the discharge samples than in the reference samples. The discharge samples were

composed primarily of the Chironomidae *Microtendipes sp.* while the reference samples were composed primarily of *Parakiefferiella sp.* Similar numbers of *Hygrobetes sp* (Acarina) were collected at both sites as were the numbers of *Asellus sp* (Isopoda). These unidentified *Asellus sp* were probably *Asellus intermedius.* *Hyalella azteca* was the dominant Amphipoda at the reference sites while *Gammarus pseudolimnaeus* was dominant at the discharge sites. The number of Mollusca organisms was low at both sampling locations. *Dreissena polymorpha* (zebra mussel) were not present in the December samples.

May/December Comparison

There was a general decrease in the number of taxa and number of organisms from May to December (Figures 3.1-1, 2) at all sampling locations. Immature Tubificidae were dominant at all sites in both months while the numbers of Mollusca decreased sharply in the December samples. *Hygrobetes sp* was the dominant Acarina in both sampling periods. Similar numbers of this species were collected in the May and December discharge samples and December reference samples. The number of *Hygrobetes sp* in the May reference samples were slightly lower. The number of Amphipoda organisms were similar at the May and December reference sites as were the numbers at the May and December discharge sites. Chironomidae *Cladotanytarsus sp* and *Dicrotendipes sp* numbers were high in May however they were absent or present only in low numbers in December. *Parakieferiella sp* (Chironomidae) were present only in the December samples.

The sampling sites were very similar in the May and December sampling periods (Appendix A). The benthic samples were generally collected from a cobble and boulder substrate at a water depth of 10.0 to 10.5 m. Bottom water temperatures were slightly higher at the May discharge locations ($\bar{X}$ = 8.9°C) than at the May reference sites ($\bar{X}$ = 7.7°C). Conversely, the December reference water temperatures ($\bar{X}$ = 4.1°C) were slightly elevated above the December discharge water temperatures ($\bar{X}$ = 3.7°C).

Statistical Analysis

Box plots of the number of organisms in the reference and discharge samples are presented in Figure 3.1-3. The box plots indicated no significant variation in the number of organisms collected at the reference sites in May and December. Similarly, no significant variation was evident between the May and December discharge samples. The variation between the number of organisms in the reference and discharge samples was also not significant.

Box plots of the number of taxa in the benthic samples indicated significant differences within the reference samples (Figure 3.1-4). No significant variation was apparent in the number of taxa

present in the May and December discharge samples and December reference samples.

These results indicated that the discharge of chlorine residues probably did not influence the benthic community composition at Darlington NGS.

3.2 Lakeview TGS

May Sampling

The zoobenthos results for the 9 reference and 9 discharge sampling locations are presented in Appendix E. These results are summarized in Appendix F.

Table 3.2-1

Zoobenthic Community By Taxonomic Group
Lakeview TGS, 1990

MAY

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
ACARINA	1	4	0.1	1	2	0.6
AMHIPODA	1	4	0.1	1	78	23.2
ISOPODA	0	0	0.0	1	9	2.6
DIPTERA	8	273	7.2	7	93	27.7
MOLLUSCA	1	7	0.2	3	85	25.3
GASTROPODA	1	2	0.0	2	5	1.4
OLIGOCHAETA	6	3511	92.4	4	64	19.0

DECEMBER

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
ACARINA	1	12	0.2	1	1	0.0
AMPHIPODA	4	534	9.8	3	127	5.9
ISOPODA	2	152	2.8	2	24	1.1
DIPTERA	10	118	2.2	2	6	0.3
MOLLUSCA	4	14	0.2	0	0	0.0
GASTROPODA	3	7	0.0	0	0	0.0
OLIGOCHAETA	7	4586	84.6	8	1990	92.6

- number of organisms

The Lakeview TGS zoobenthic population consisted of the 7 major taxonomic groups as presented in Table 3.2-1. All 7 groups were represented in the discharge samples while only 6 groups were present in the reference samples. Diptera and Oligochaeta comprised the major taxonomic groups in the reference samples while Diptera was the major taxonomic group in the discharge samples. The greatest number of organisms present in the reference samples were Oligochaeta which comprised 92.4% of the population. The number of organisms present in the discharge samples were distributed primarily between 4 taxonomic groups. The percentage composition of Diptera, Isopoda and Mollusca were similar with only slightly fewer Oligochaeta present in the samples.

The number of organisms present in the reference samples (n = 3 801 organisms) greatly exceeded the number in the discharge samples (n = 336, Figure 3.2-1). The majority of reference organisms were collected primarily at one sampling location (n = 2 555 organisms). The mean number of organisms in the other reference samples was 623. The mean number of organisms collected in the discharge samples was 112 organisms.

Twenty-four taxa were identified in the reference and discharge samples (Figure 3.2-2). The number of taxa in the reference samples ranged from 9 to 15. These taxa represented a combined total of 18 taxa in the reference samples. The discharge sample site taxa ranged in number from 11 to 14 and represented a combined total of 19 taxa.

Oligochaeta, represented primarily by immature Tubificidae, was the dominant taxa in the reference samples. The immature Tubificidae composed 87.9% of the total number of organisms. The Tubificidae *Limnodrilus hoffmeisteri* (3.4%) and the Chironomidae *Psectrocladius sp* (3.4%) were the other major reference sample benthic species. The discharge samples were not dominated by one major group. Instead, the Amphipoda *Gammarus fasciatus* (23.2%), immature Tubificidae (17.9%) and the Mollusca *Pisidium compressum* (15.2%) were the major benthic organisms. *Dreissena polymorpha* (zebra mussel) were not present in the reference or discharge samples.

December Sampling

The December zoobenthic community consisted of 7 taxonomic groups (Table 3.2-1). All 7 taxonomic groups were present in the reference samples while only 5 taxonomic groups were represented in the discharge samples. Diptera and Oligochaeta comprised the major taxonomic groups in the reference samples while Oligochaeta was the predominant taxa in the discharge samples. The greatest number of organisms in both the reference and discharge samples were Oligochaeta. Oligochaeta comprised 84.6% and 92.6% of the total number of organisms in the reference and discharge samples respectively.

The total number of organisms in the reference samples (n = 5 423 organisms) greatly exceeded the number in the discharge samples (n = 2 148, Figure 3.2-1). The mean number of reference and discharge sampling site organisms were 1 808 and 716 respectively. The number of discharge organisms at each sampling site ranged from 252 to 1 022 organisms.

A total of 35 taxa were identified in the December samples (Figure 3.2- 2). The majority of the taxa were present in the reference samples (n = 31) while the discharge samples were composed of only 16 taxa.

Immature Tubificidae were the dominant organisms present in the reference (82.6%) and discharge (78.8%) samples. The reference samples were also composed of the Amphipoda *Gammarus sp* (6.3%) and *Gammarus fasciatus* (2.0%). Isopda were also represented by *Asellus sp* which comprised 2.1% of the total number of organisms. The Tubificidae *Quistadrilus multisetosus* (6.4%), the Naididae *Nais barbata* (4.1%) and the Amphipoda *Gammarus sp* 4 (3.4%) were the other major discharge species. *Dreissena polymorpha* were present in low numbers (n = 7) only in the reference samples.

May/December Comparison

The number of taxa and the total number of organisms increased at both the reference and discharge sampling locations from May to December (Figures 3.2-1, 2). Immature Tubificidae were the predominant organism in both sampling periods also increasing in number from May to December. The number of Chironomidae declined from May to December with only a very low number of individuals present in the December discharge samples (n = 6). However the number of Amphipoda in the reference samples increased from a low of 4 organisms in May to 534 in December. Naididae were present primarily in the December discharge samples (n = 154 organisms).

Variation was present in the sampling sites (Appendix A). Reference and discharge sampling site substrate compositions were generally similar within collections. However, the May and December sampling site substrates were not similar. The May samples were collected from a predominantly sand-silt substrate while the December samples were retrieved from rocky or cobble-boulder substrates. Zero visibility in the discharge prevented the divers from searching for a sand-silt substrate in December.

The discharge samples were collected from a shallower depth ($\bar{X}$ = 4.0 m) than the reference samples ($\bar{X}$ = 7.0 m) due to shoreline configuration in the vicinity of Lakeview TGS. The discharge bottom water temperatures were also elevated approximately 5.5°C above the respective reference bottom water temperatures in both sampling periods.

Statistical Analysis

Box plots of the total number of organisms collected in the Lakeview TGS samples indicated there was a significant increase in the number of organisms present in the discharge samples from May to December (Figure 3.2-3). However, the increase in the number of organisms in the reference samples from May to December was not significant. The total number of organisms in the December reference and discharge samples were marginally not significantly different.

Statistical analysis of the number of taxa present in the samples indicated a significant increase of taxa in the reference samples from May to December (Figure 3.2-4). The December reference samples were also composed of significantly more taxa than the December discharge samples. However the May and December discharge samples were not significantly different nor were they significantly different from the May reference sample.

The results of the Lakeview TGS benthic survey indicated that there was probably no detrimental effect on the benthic community that could be attributed to chlorine residue discharge. Although the discharge richness declined, the number of organisms increased in both the reference and discharge samples in December. Sources of variation in the benthic results were probably attributable to the differences in water temperature, substrate composition and sampling depth.

3.3 Lambton TGS

Mav Sampling

The Lambton TGS zoobenthos results for the 9 reference and 9 discharge sampling locations are presented in Appendix G. These results are summarized in Appendix H.

The May Lambton TGS zoobenthic community consisted of 5 major taxonomic groups as presented in Table 3.3-1. All 5 taxonomic groups were represented in the reference site samples, however only 4 were present in the discharge site samples. Oligochaeta and Diptera were represented by the most taxa/groups in the reference samples. The same major taxonomic groups were predominant in the discharge samples, however the number of Diptera taxa/groups was greater than the number of Oligochaeta taxa. The greatest number of organisms in the reference samples were Diptera (55.8%) and Oligochaeta (43.1%). The greatest number of organisms in the discharge community were Oligochaeta (68.3%) and Diptera (24.0%).

The number of organisms in the reference sites (n = 1 381) greatly exceeded the number in the discharge sites (n = 404, Figure 3.3-1). The majority of the reference site organisms were present primarily at one sample location. The mean number of organisms collected at

the reference sites was 460 organisms. The variation in number was less in the discharge samples however the mean number of organisms collected was only 135.

A total of 24 taxa were represented in the reference site samples (Figure 3.3-2). This total slightly exceeded the 21 taxa present in the discharge samples. The number of taxa present at the sampling sites ranged from 12 to 16 at the reference locations and 9 to 14 at the discharge locations.

Table 3.3-1

Zoobenthic Community By Taxonomic Group
Lambton TGS, 1990

MAY

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
DIPTERA	8	770	55.8	9	97	24.0
MOLLUSCA	1	2	0.1	3	24	5.9
TRICOPTERA	2	7	0.5	2	7	1.7
OLIGOCHAETA	10	595	43.1	7	276	68.3
EPHEMEROPTERA	3	7	0.5	0	0	0.0

DECEMBER

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
AMPHIPODA	0	0	0.0	1	8	0.5
DIPTERA	5	589	29.0	3	18	1.1
LEPIDOPTERA	1	4	0.2	1	4	0.2
MOLLUSCA	1	6	0.3	4	5	0.3
TRICOPTERA	1	10	0.5	3	20	1.2
OLIGOCHAETA	10	1428	70.2	5	1653	96.8

- number of organisms

The Diptera *Polypedilum sp* (44.1%) was the dominant organism in the reference site benthic community. Immature Tubificidae (28.3%), the Naididae *Paranais frici* (6.2%) and the Chironomidae *Phaenopsectra sp* (4.9%) were the other major reference taxa. The

discharge population was composed primarily of immature Tubificidae (59.2%) and the Chironomidae *Polypedilum sp* (17.3%). *Dreissena polymorpha* (zebra mussel) were not present in the benthic samples, however 1 *Corbicula fluminea* (Asiatic clam) specimen was present in one discharge sample.

December Sampling

A total of 6 major taxonomic groups were present in the December benthic samples. All of these taxonomic groups were represented in the discharge samples while only 5 were present in the reference site samples. Oligochaeta was represented by the most taxa/groups at both the reference and discharge locations. Diptera was the other major taxonomic group in the reference samples while Mollusca, Diptera and Tricoptera were the other major discharge taxonomic groups. The greatest number of organisms in the reference (70.2%) and discharge (96.8%) samples were Oligochaeta.

The greatest number of organisms were collected at the reference sites (Figure 3.3-1). The mean number of organisms at the reference sites ($\bar{X}$ = 677 organisms per site) slightly exceeded the mean number of organisms at the discharge sample sites ($\bar{X}$ = 570 organisms). The number of organisms in the discharge samples was very variable, ranging from 46 to 1102 organisms per site. The variability in the number of organisms at the reference sites was less.

A total of 25 taxa were collected in the December sample period (Figure 3.3-2). Eighteen taxa were present in the reference samples while 17 were present in the discharge samples. The number of taxa was similar at the reference locations ranging in number from 11 to 14 however the variation in number of taxa was greater in the discharge samples (3 to 11 taxa per sample site).

Tubificidae were predominant in the reference and discharge samples. Immature Tubificidae composed 63.6 and 94.2% of the number of organisms in the reference and discharge samples respectively. The Chironomidae *Stictochironomous sp* (15.2%) and *Phaenopsectra sp* (8.9%) were the other major organisms in the reference benthic community. *Dreissenia polymorpha* (zebra mussel) were not present in the December samples, however 2 *Corbicula fluminea* (Asiatic clam) specimens were present in one discharge replicate sample.

May/December Comparison

The total number of taxa declined from May to December at both the reference and discharge locations (Figure 3.3-2). However the total number of organisms increased in December at both sampling locations (Figure 3.3-1). Immature Tubificidae were the predominant organism at all locations in both sampling periods.

The number of Chironomidae declined from May to December at both locations with a very low number of individuals present in the December discharge samples (n = 18).

Corbicula fluminea (Asiatic clam) were present in the Lambton TGS discharge in low numbers on both sampling occasions. These molluscs have been reported to present potential biofouling problems in water intake systems (White, Winnell and Jude, 1984).

Variation was present between the reference and discharge benthic sampling sites (Appendix A). Sampling depths were similar however the reference location substrates were generally composed of a greater silt component than the discharge locations. The discharge bottom water temperatures ($\bar{X}$ = 12.8°C) were slightly elevated above the reference sites ($\bar{X}$ = 11.0°C) in May. However, the December discharge bottom water temperatures ($\bar{X}$ = 9.8°C) were highly elevated above the reference site temperatures ($\bar{X}$ = 3.3°C).

Statistical Analysis

No significant variation was apparent in the number of organisms at the reference and discharge locations in May or at the reference and discharge locations in December (Figure 3.3-3). The differences between the May and December benthos density numbers were also not significant at the reference sites and at the discharge sites. The variation in taxa richness was also not significant when analyzed on a sampling location or sampling period basis (Figure 3.3-4).

These results indicated that chlorine residue discharge probably did not affect the Lambton TGS benthic community. The variation in substrate composition and elevated discharge water temperatures did not also appear to significantly alter the benthic community total organisms or taxa composition.

3.4 Nanticoke TGS

May Sampling

The Nanticoke TGS zoobenthos sampling results for the individual sampling site are presented in Appendix I. The individual site results are summarized in Appendix J.

The May Nanticoke TGS zoobenthic community consisted of 8 major taxonomic groups (Table 3.3-4). Seven of the taxonomic groups were present in the reference samples while only 6 were presented in the discharge samples. Diptera and Mollusca were represented by the most taxa in the reference samples while the majority of the discharge taxa were present in the Mollusca and Oligochaeta taxonomic groups. The greatest number of organisms were Mollusca in both the reference (72.6%) and discharge samples (94.7%).

Oligochaeta also comprised 16.2% of the reference sites benthic community.

The number of organisms in the discharge samples ($\bar{x}$ = 2 054 organisms) greatly exceeded the number in the reference samples ($\bar{x}$ = 641 organisms, Figure 3.4-1). However the majority of the discharge organisms were present at only one sample location. Less variation was evident in the range in number of organisms at the reference locations (555 to 759 organisms).

A total of 35 taxa were represented in the May samples (Figure 3.4-2). Thirty-one taxa were present in the reference site community while only 12 were present in the discharge community. The number of taxa varied from 11 to 24 at the reference sites. The number of taxa at the discharge sample locations ranged from 3 to 8.

Table 3.4-1

Zoobenthic Community By Taxonomic Group
Nanticoke TGS, 1990

MAY

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
ACARINA	1	2	0.1	0	0	0.0
AMPHIPODA	1	48	2.5	1	282	4.6
DIPTERA	14	160	8.3	2	9	0.1
MOLLUSCA	7	1 397	72.6	4	5 836	94.7
TRICOPTERA	3	3	0.2	0	0	0.0
OLIGOCHAETA	4	311	16.2	3	30	0.5
HIRUDINEA	1	2	0.1	1	1	0.0
EPHEMEROPTERA	0	0	0.0	1	3	0.0

DECEMBER

	REFERENCE			DISCHARGE		
TAXONOMIC GROUP	NUMBER OF TAXA	#	%	NUMBER OF TAXA	#	%
AMPHIPODA	3	224	16.2	2	704	83.6
DIPTERA	12	262	18.9	2	10	1.2
MOLLUSCA	5	217	15.7	1	118	14.0
OLIGOCHAETA	4	675	48.8	1	10	1.2
HIRUDINEA	1	6	0.4	0	0	0.0

- number of organisms

The Mollusca *Dreissena polymorpha* (zebra mussel) was the dominant organism collected in the discharge and reference samples. It comprised 94.7% of the discharge sample and 72.0% of the reference sample. The Tubificidae *Spirosperma ferox* (15.1%), the Chironomidae *Pseudochironomus sp* (3.5%) and the Amphipoda *Gammarus fasciatus* (2.5%) were also present in the reference site benthic community. *Gammarus fasciatus* (4.6%) was the only other major species in the discharge benthic samples. Chironomidae numbers were much lower in the discharge samples (n = 9 organisms) than in the reference samples (n = 160 organisms).

December Sampling

The Nanticoke TGS December zoobenthic community was composed of 5 major taxonomic groups (Table 3.4-1). All 5 taxonomic groups were represented in the reference samples, however only 4 were present in the discharge samples. Diptera and Mollusca were represented by the most taxa/groups in the reference samples. However, the greatest number of organisms in the reference samples were Oligochaeta (48.4%). Similar percentages of Diptera, Amphipoda and Mollusca organisms were also present in the reference samples. Diptera and Amphipoda were represented by the most taxa/groups in the discharge samples. Amphipoda and Mollusca formed 83.6 and 14.0% of the discharge community respectively.

The majority of organisms were present in the reference samples (Figure 3.4-1). The mean number of reference and discharge organisms per sample site were 461 and 281 organisms respectively. The number of organisms collected in the reference samples ranged from 139 to 887 while the range in the number of organisms in the discharge samples was from 46 to 675.

The December benthic community was composed of 25 taxa (Figure 3.4-2). All 25 taxa were present in the reference samples while only 6 taxa were represented in the discharge samples. The number of taxa in the discharge samples ranged from 3 to 6.

Immature Tubificidae (Oligochaeta) were the dominant organism in the reference samples. They composed 44.3% of the reference samples. The Mollusca *Dreissenia polymorpha* (zebra mussel, 15.0%), Amphipoda *Gammarus fasciatus* (12.6%) and the Diptera *Procladius sp* (7.0%) were the other major benthic organisms in the reference samples. The discharge benthic samples were composed primarily of the Amphipoda *Gammarus fasciatus* (49.8%) and *Gammarus sp* (33.8%) and the Mollusca *Dreissenia polymorpha* (zebra mussel, 14.0%). The number of Chironomidae was greater in the reference samples (n = 262 organisms) than in the discharge samples (n = 10 organisms).

May/December Comparison

The total number of organisms declined from the May to December sampling period (Figure 3.4-1). The reason for the decline was primarily related to the decrease in the number of *Dreissena polymorpha* (zebra mussel) present in the samples. The taxa diversity also decreased from May to December (Figure 3.4-2). The decrease was very notable in the discharge samples when the number of taxa declined from 12 in May to 6 in December. Amphipoda numbers increased from May to December at both reference and discharge locations. The number of Chironomidae also increased slightly in the reference samples in December however their abundance continued to be very low in the discharge samples. The numbers of immature Tubificidae increased in the reference samples but declined slightly in the discharge samples.

The substrate composition and sampling depths were generally similar between the reference and discharge sampling sites in May and December. The May bottom water temperatures were also similar between the reference and discharge locations. However the December discharge bottom water temperatures ($\bar{X}$ = 12.9°C) were highly elevated above the respective reference temperatures ($\bar{x}$ = 3.3°C).

Statistical Analysis

Analysis of the density box plots of the Nanticoke TGS site benthic community, indicated there was no significant variation between reference and discharge sampling locations when analyzed on a May or December sampling period basis (Figure 3.4-3). The December discharge benthic organism density was significantly lower than the May reference density however, it was not significantly lower than the December reference density.

Significant variation was evident in the number of taxa present at the sampling locations during both sampling periods (Figure 3.4-4). However no significant variation was apparent between the number of taxa collected in either the May or December discharge samples.

The benthic study results indicated chlorine residue discharge probably did not affect the discharge benthic community. The reference May and December benthic densities were not significantly different than the respective discharge densities. No significant alteration was indicated in the discharge benthic community richness after chlorination. The difference in reference and discharge richness values may possibly be attributed to the elevated discharge water temperatures.

3.5 Sources of Variation

The density and richness of the benthic communities at the reference and discharge locations could be influenced by a number of factors other than chlorination. These factors could contribute to variation within the benthic community.

a) Water Temperature

Elevated discharge water temperatures have been shown to be contributing sources of advanced benthic organism development (OHRD Report C80-133-H). Advanced development can lead to earlier dispersal of some organisms (ie Chironomidae) from the discharge areas than from areas influenced by the ambient lake temperatures. This dispersal can contribute to the variation in the number of organisms and species present at lake reference and discharge locations.

Elevated water temperatures may also attract benthic organisms to the discharge areas. Some benthic organisms may emigrate to the warmer discharge waters as lake ambient water temperatures decline below the species temperature preferendum (H. Kowalyk, pers comm).

The effects of elevated water temperatures on the benthic communities in the present study could not be addressed due to the lack of comparable discharges within the study area.

b) Substrate Composition

Variation within the reference and discharge substrate composition can influence the benthic community composition. An increase in the silt component within the substrate composition can lead to an increase in the number of Tubificidae organisms and species present within the community.

Sampling of areas of different substrate composition was minimized within the present study by the divers selecting the sampling sites. However variation was present in the silt component at Lambton TGS and the sand and cobble-boulder components at Lakeview TGS.

Substrate composition also influenced the depth of benthic sampling and therefore the area sampled. Finer substrate components were removed more readily than coarser materials with the air lift sampling system. The divers attempted to sample the same size area however visibility and substrate composition did not always permit exact duplication.

4. SUMMARY

1. Discharge and reference site benthic communities were sampled with an air lift system prior to and within approximately 2 weeks after the discharge of chlorine for zebra mussel control at 4 generating stations (Darlington NGS and Lakeview, Lambton and Nanticoke TGS.

2. The highest density of benthic organisms was present at the Nanticoke TGS discharge in May. The majority of these organisms were zebra mussels. The lowest number of benthic organisms were present in the Lambton TGS December discharge samples.

3. Species richness was highest within the Darlington NGS May reference samples. The lowest number of taxa were present in the Nanticoke TGS December discharge samples.

4. No significant variation was apparent in benthic density or benthic richness at the Darlington NGS reference and discharge sites.

5. The benthic density was significantly different at the Lakeview TGS discharge and reference sites in May. However the December discharge and reference sites total number of organisms were not significantly different. The Lakeview TGS reference site species richness values were also significantly different however, there was no significant variation in the discharge benthic richness.

6. The variations in either reference and discharge benthic density or benthic richness were not significant at Lambton TGS.

7. The benthic densities were not significantly different at Nanticoke TGS reference and discharge sites in December. Benthic richness was significantly lower in the Nanticoke TGS discharge than at the reference sites however no significant variation was apparent between the May and December discharge benthic richness values.

8. Variation within the benthic communities at each of the 4 stations surveyed was probably not attributable to the discharge of chlorine residues.

9. The Asiatic clam was present in small numbers in the Lambton TGS discharge in May (n = 1) and December (n = 2).

5. ACKNOWLEDGEMENTS

Mr. Jim Harcus collected the benthic samples and supervised the field operations. Mr. Henry Kowalyk identified the benthic samples and provided insight into the benthic community variation.

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Wilkinson, Leland. SYSTAT: The system for statistics. Evanston, Il: SYSTAT, Inc., 1990.

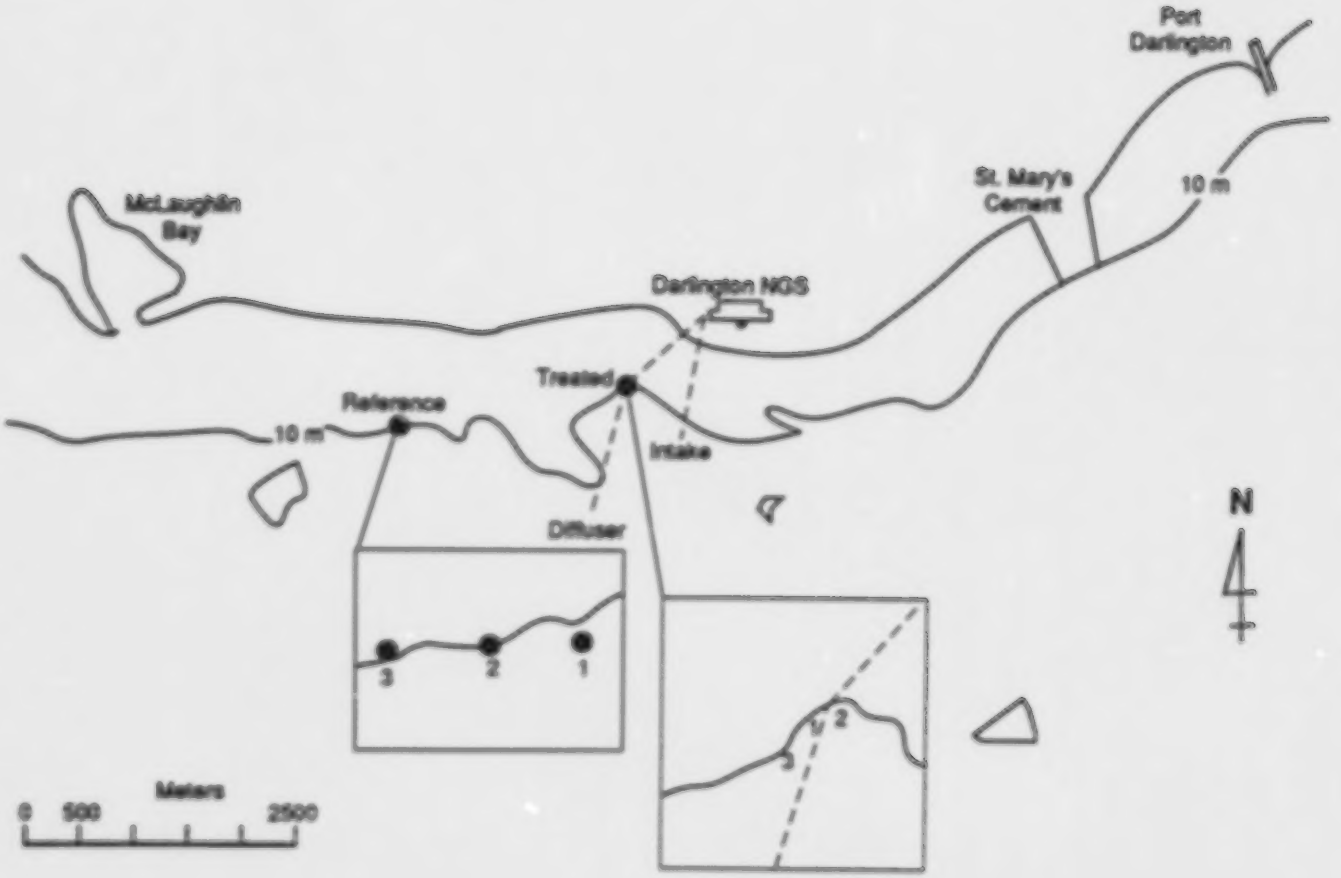


FIGURE 2.0-1

BENTHIC SAMPLING LOCATIONS
DARLINGTON NGS - 1990

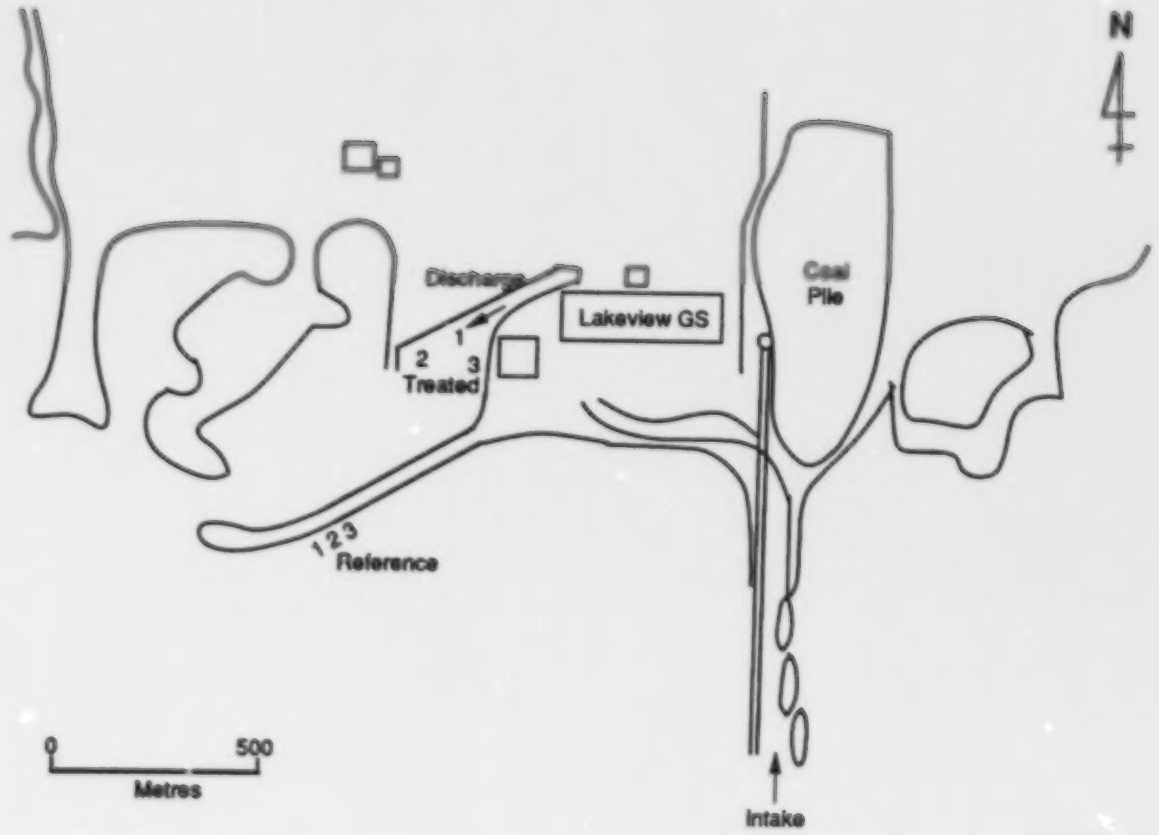


FIGURE 2.0-2

BENTHIC SAMPLING LOCATIONS
LAKEVIEW NGS - 1990

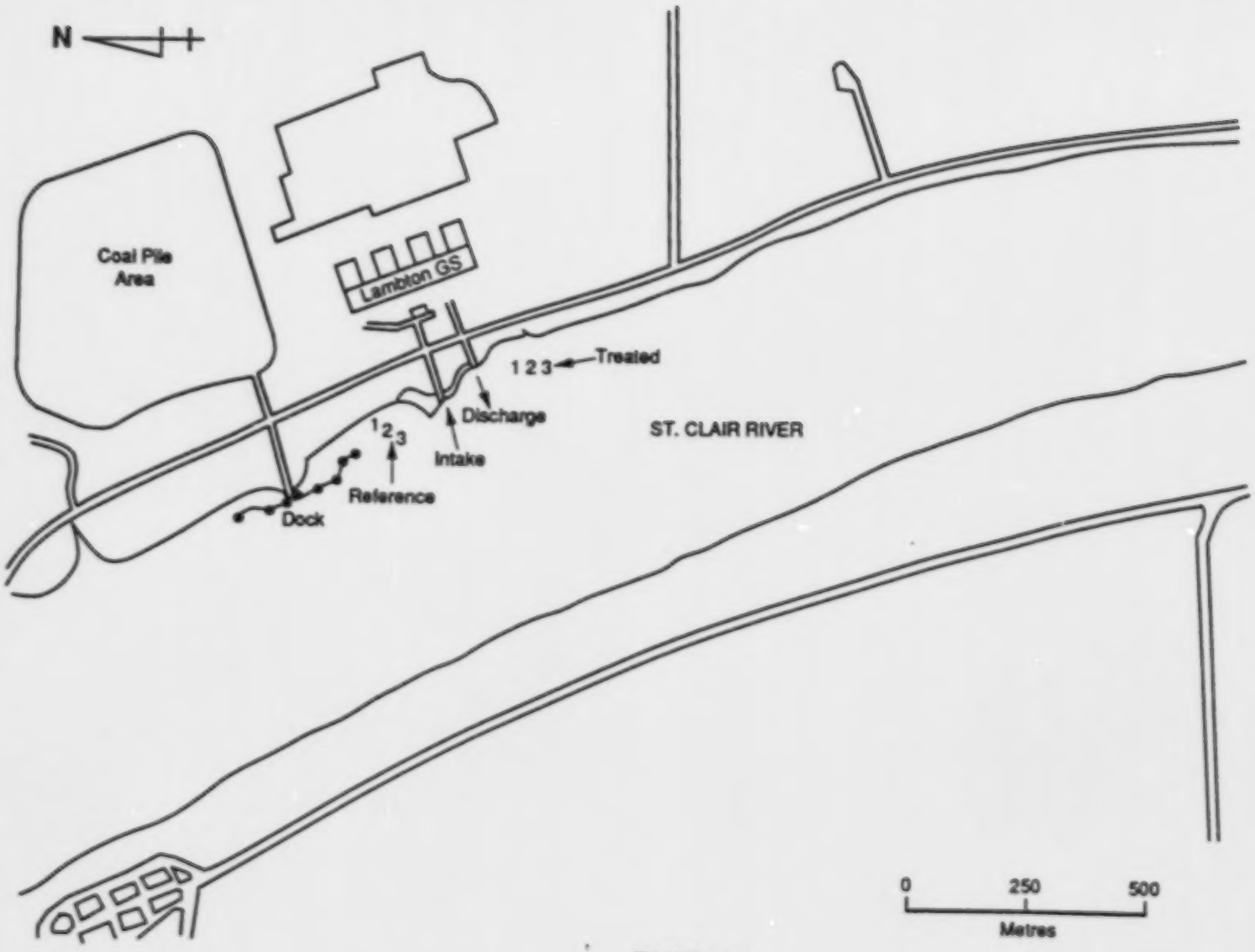


FIGURE 2.0-3

BENTHIC SAMPLING LOCATIONS
LAMBTON NGS - 1990

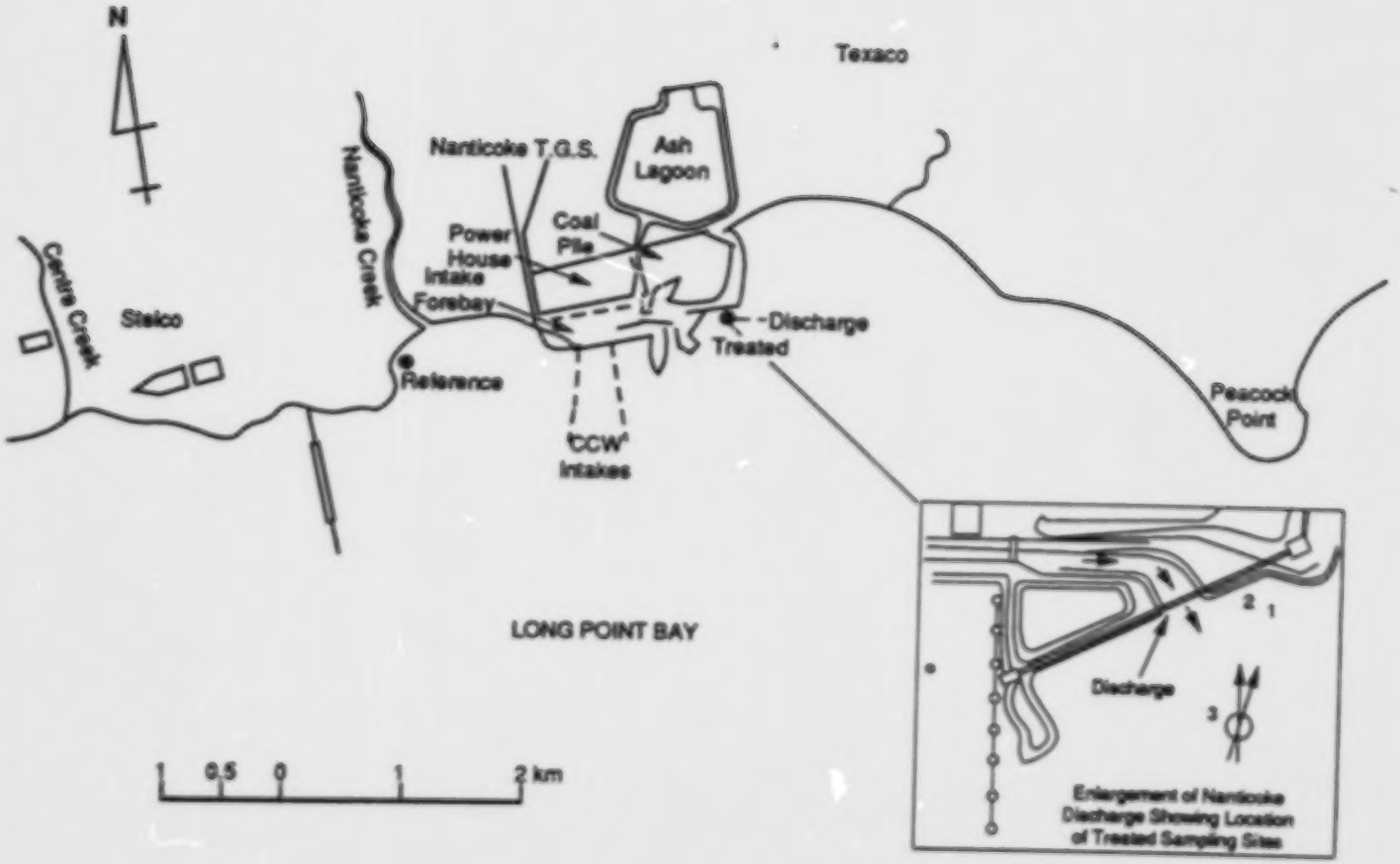


FIGURE 2.0-4

BENTHIC SAMPLING LOCATIONS
NANTICOKE TGS - 1990

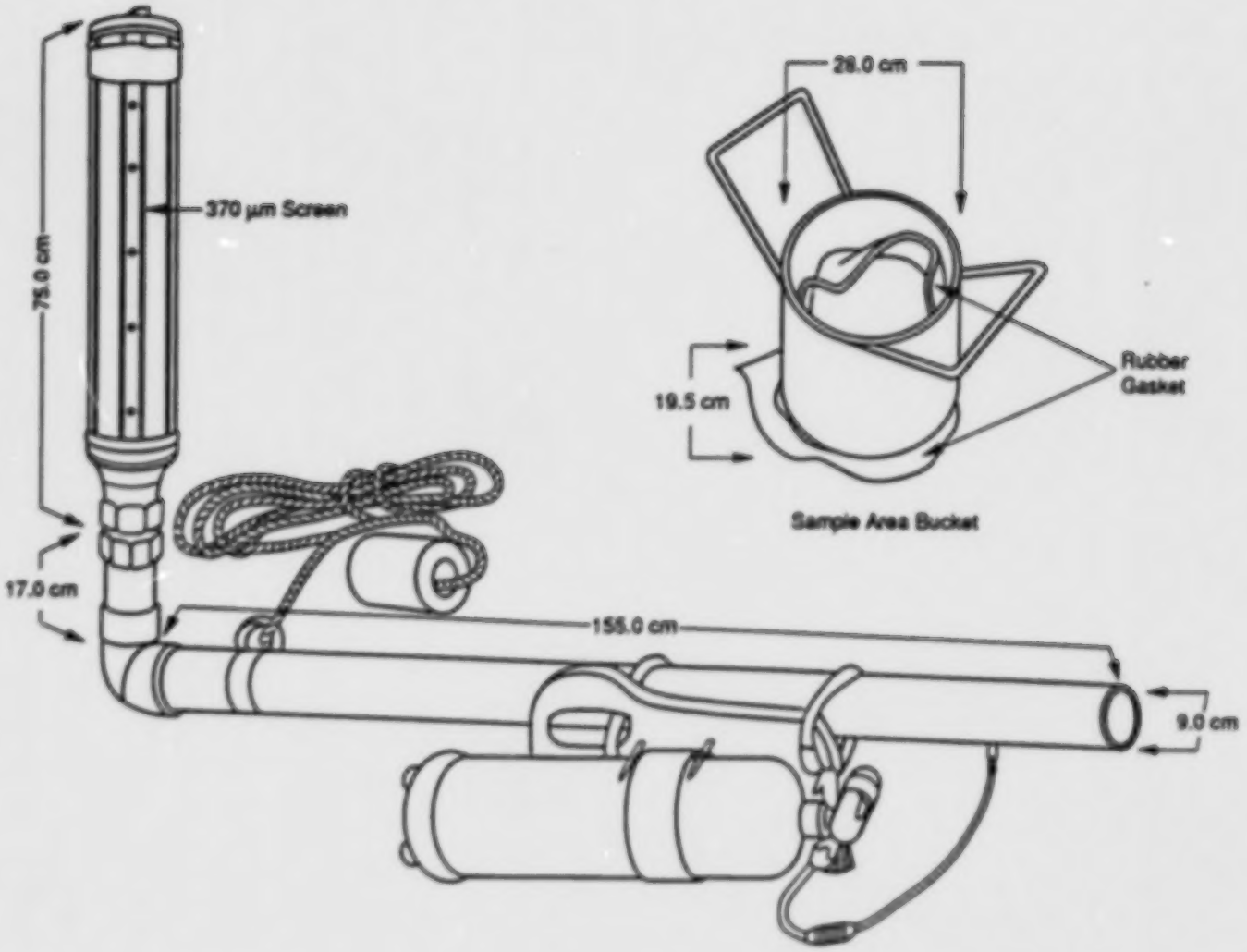
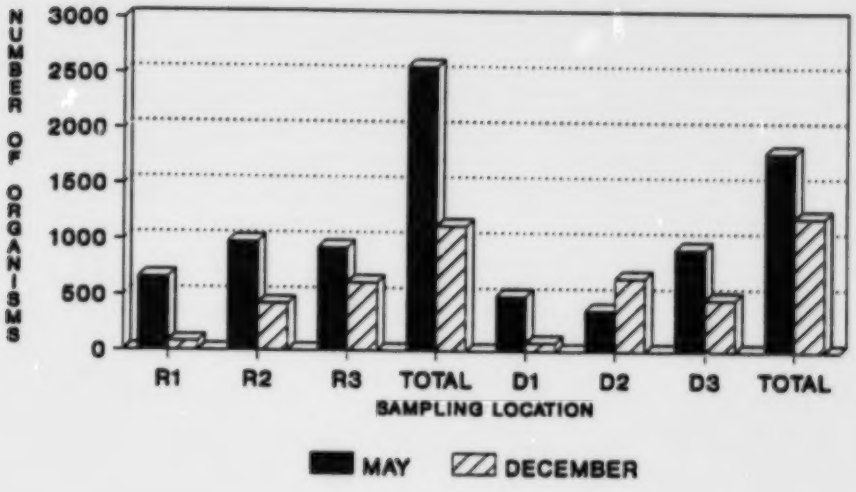


FIGURE 2.0-5

BENTHIC SAMPLING APPARATUS - 1990

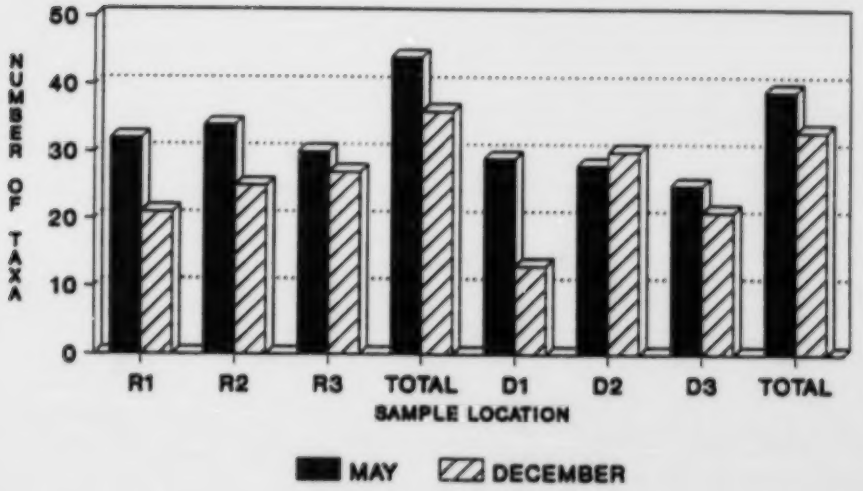
ZOOBENTHOS DENSITY
DARLINGTON NGS, 1990



R - REFERENCE D- DISCHARGE

FIGURE 3.1-1

ZOOBENTHOS RICHNESS
DARLINGTON NGS, 1990



R - REFERENCE D - DISCHARGE

FIGURE 3.1-2

ZOOBENTHOS DENSITY BOX PLOTS. DARLINGTON NGS. 1990

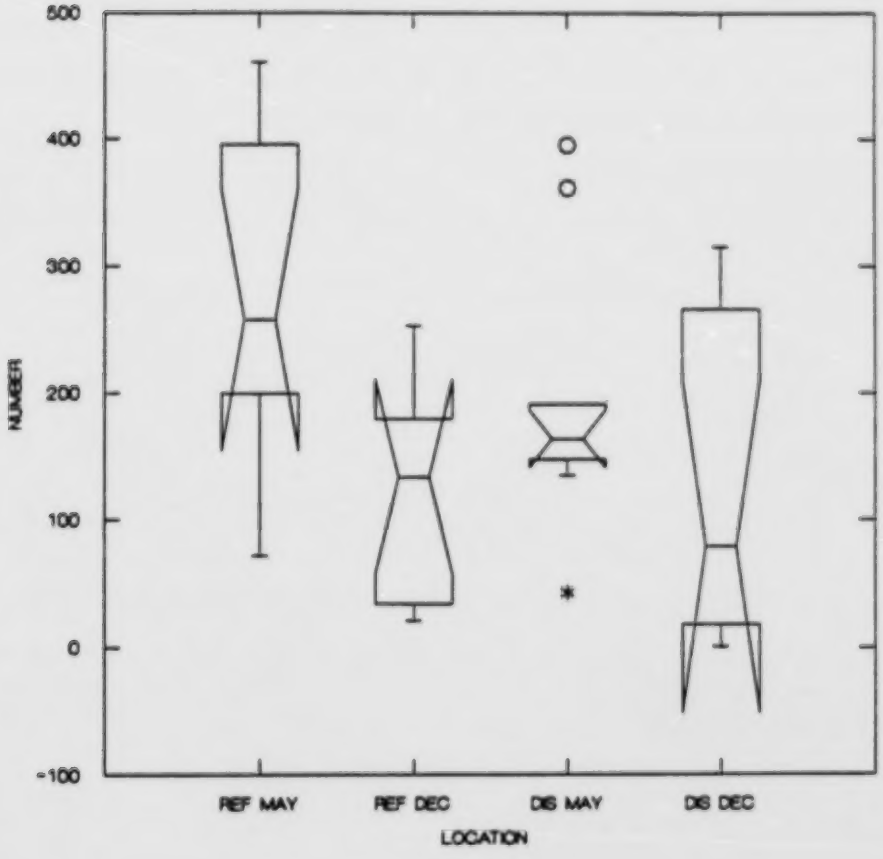


FIGURE 3.1-3

ZOOBENTHOS RICHNESS BOX PLOTS. DARLINGTON NGS. 1990

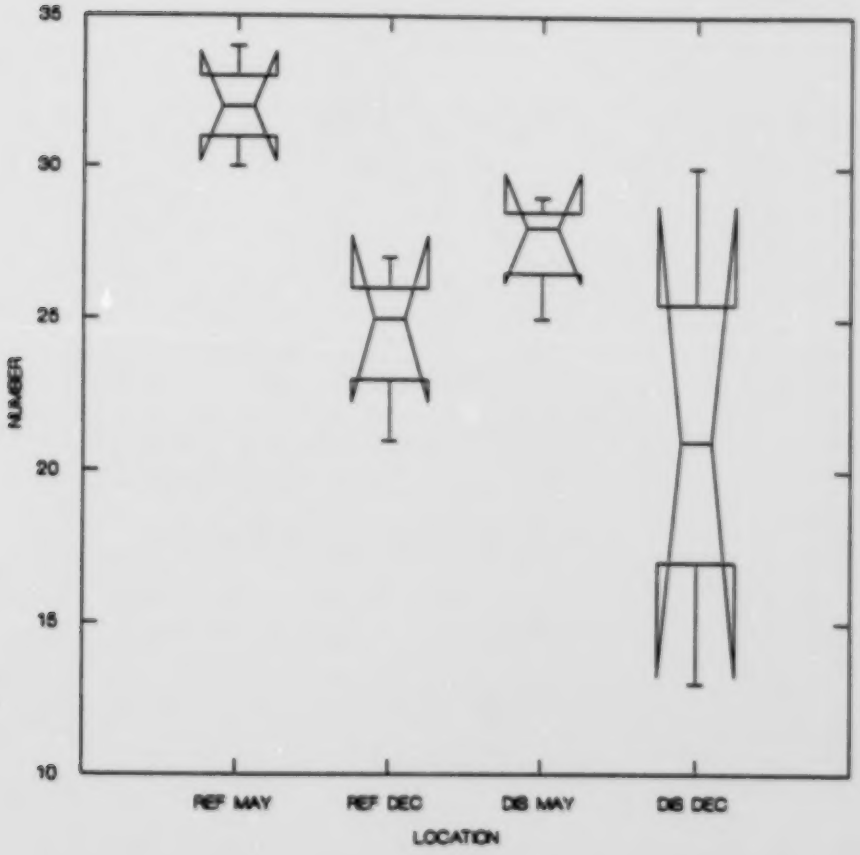


FIGURE 3.1-4

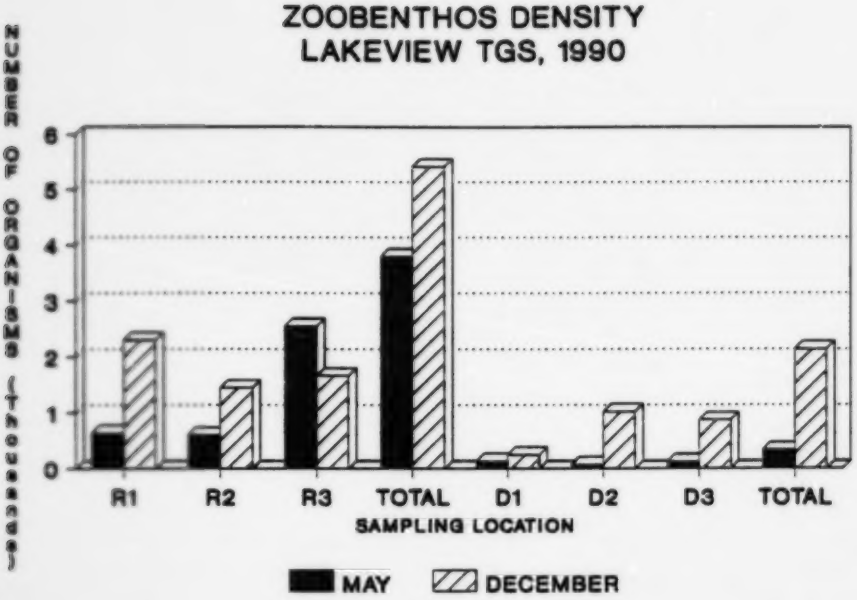


FIGURE 3.2-1

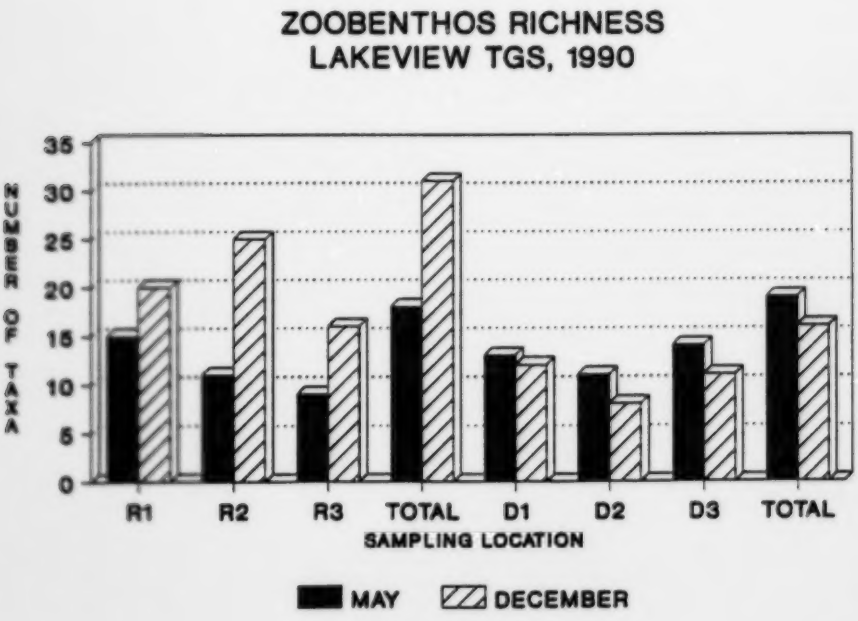


FIGURE 3.2-2

ZOOBENTHOS DENSITY BOX PLOTS. LAKEVIEW TGS. 1990

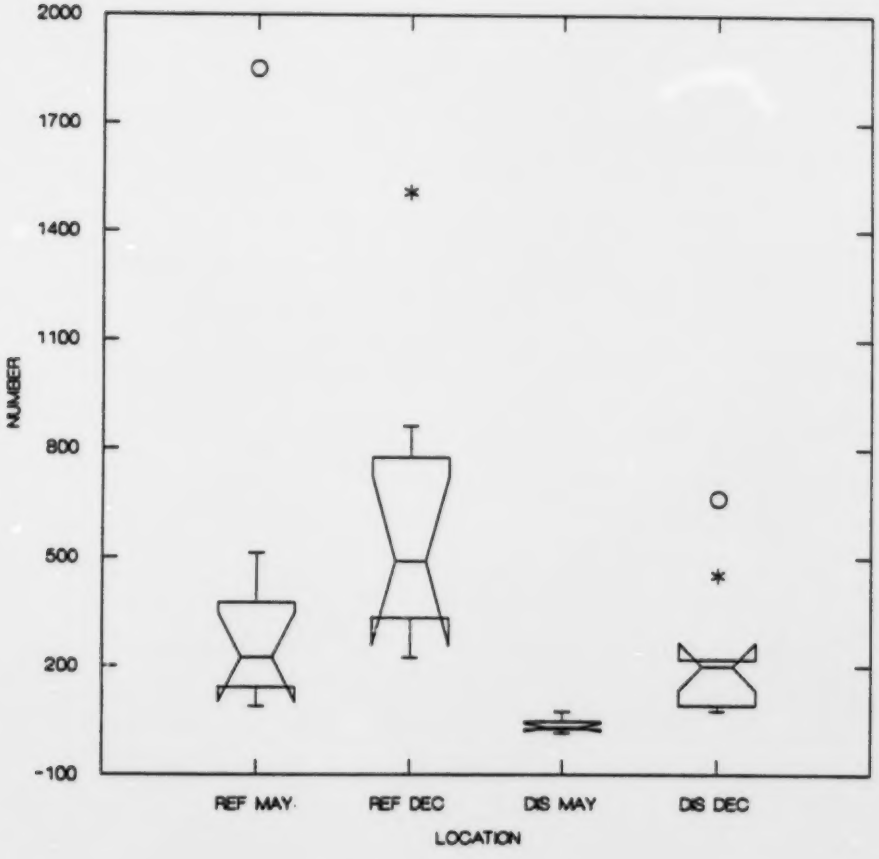


FIGURE 3.2-3

ZOOBENTHOS RICHNESS BOX PLOTS. LAKEVIEW TGS. 1990

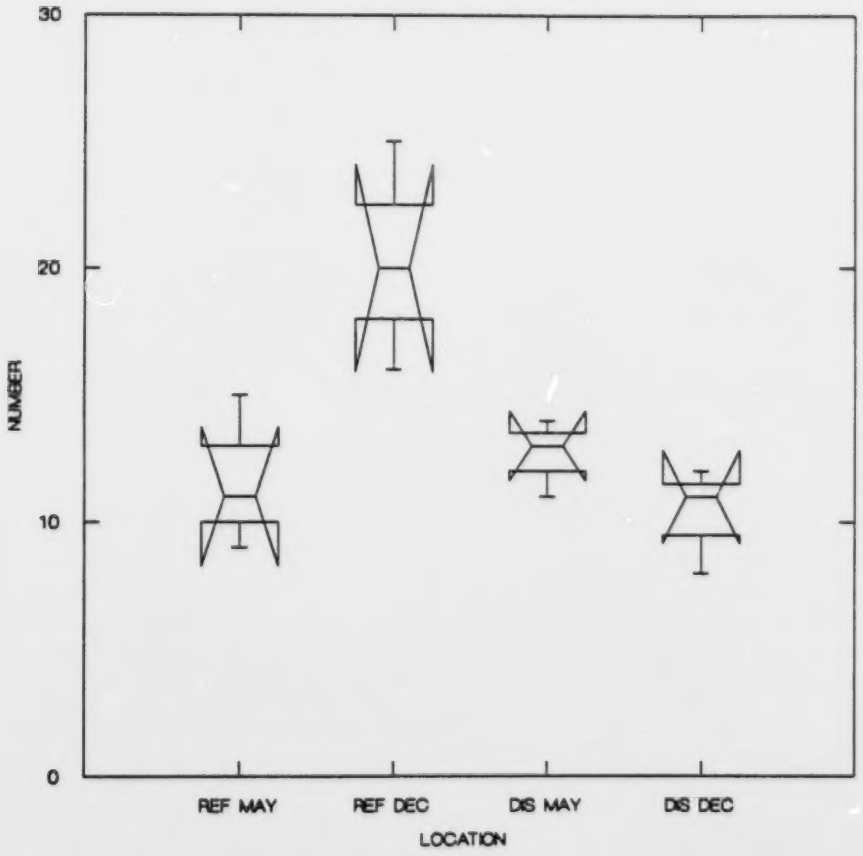
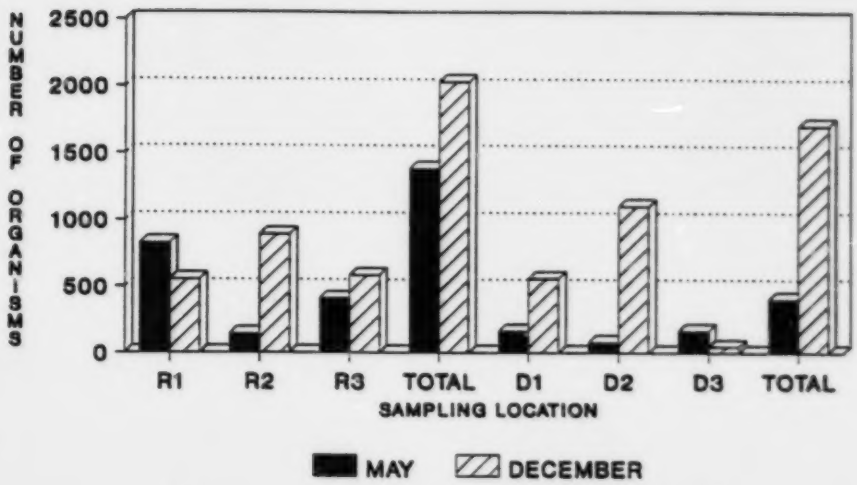


FIGURE 3.2-4

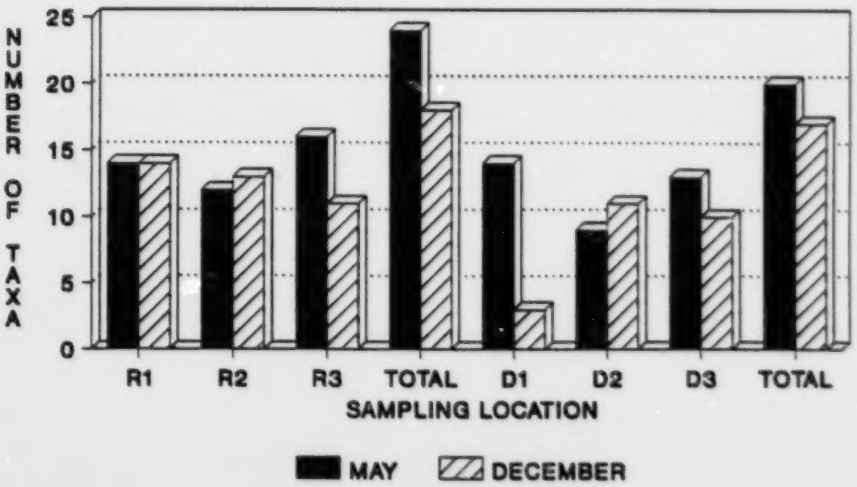
ZOOBENTHOS DENSITY
LAMBTON TGS, 1990



R - REFERENCE D - DISCHARGE

FIGURE 3.3-1

ZOOBENTHOS RICHNESS
LAMBTON TGS, 1990



R - REFERENCE D - DISCHARGE

FIGURE 3.3-2

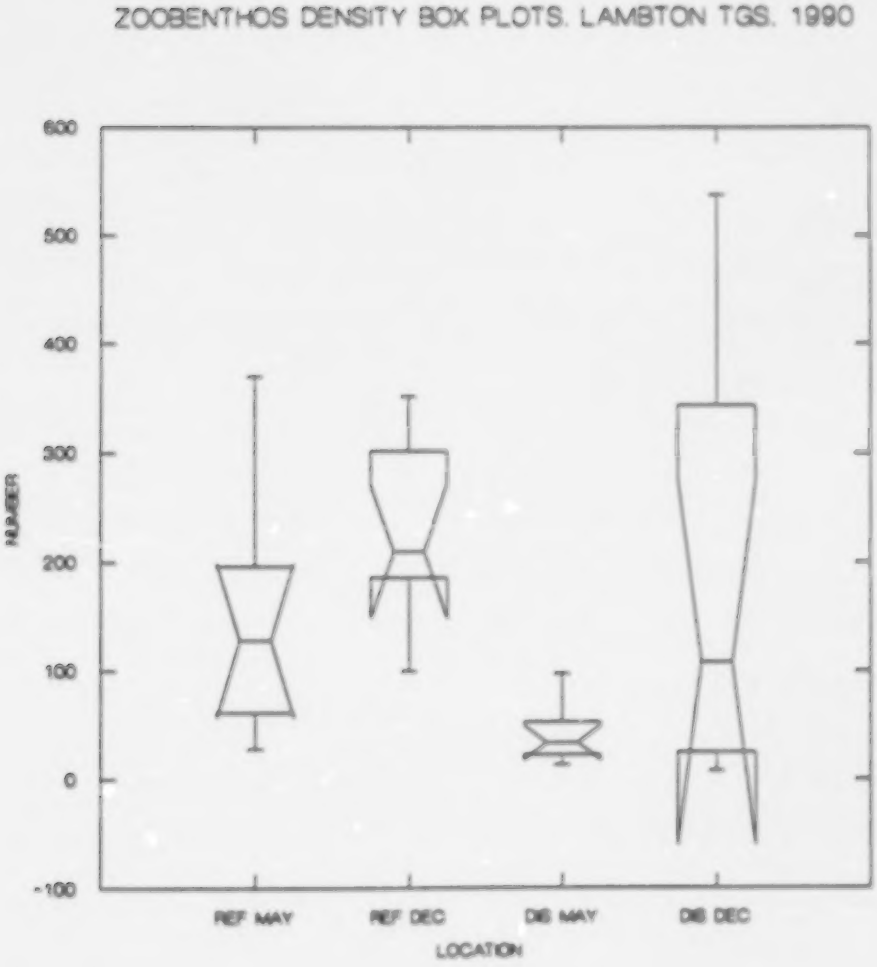

ZOOBENTHOS DENSITY BOX PLOTS. LAMBTON TGS. 1990
600
500
400
300
200
100
0
-100
NUMBER
REF MAY
REF DEC
DIS MAY
DIS DEC
LOCATION

FIGURE 3.3-3

ZOOBENTHOS RICHNESS BOX PLOTS. LAMBTON TGS. 1990

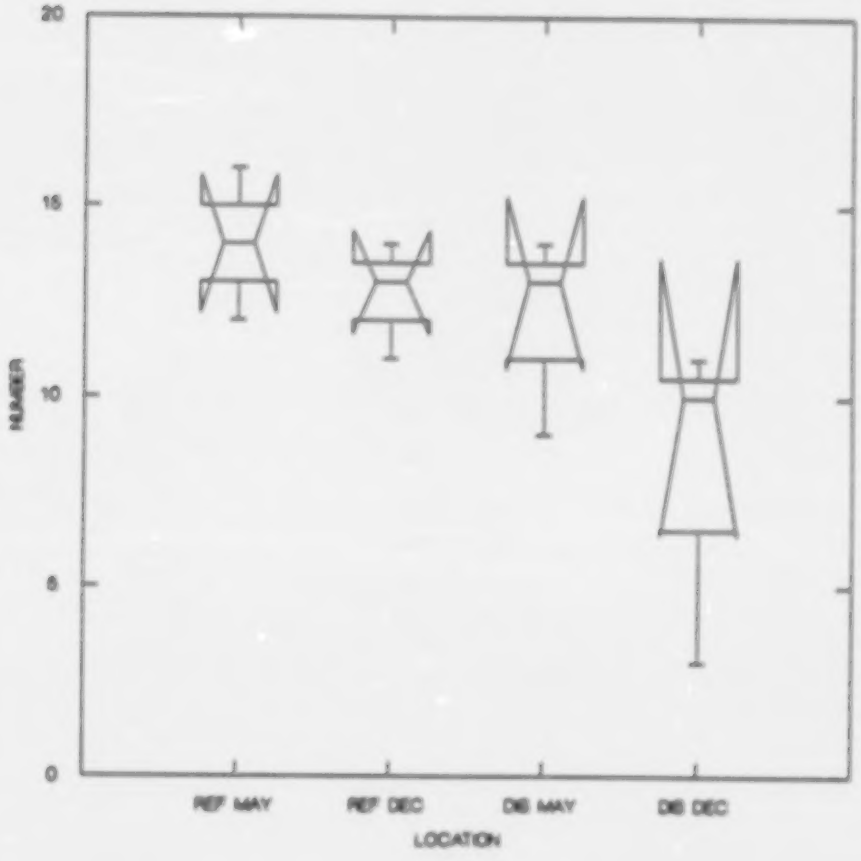


FIGURE 3.3-4

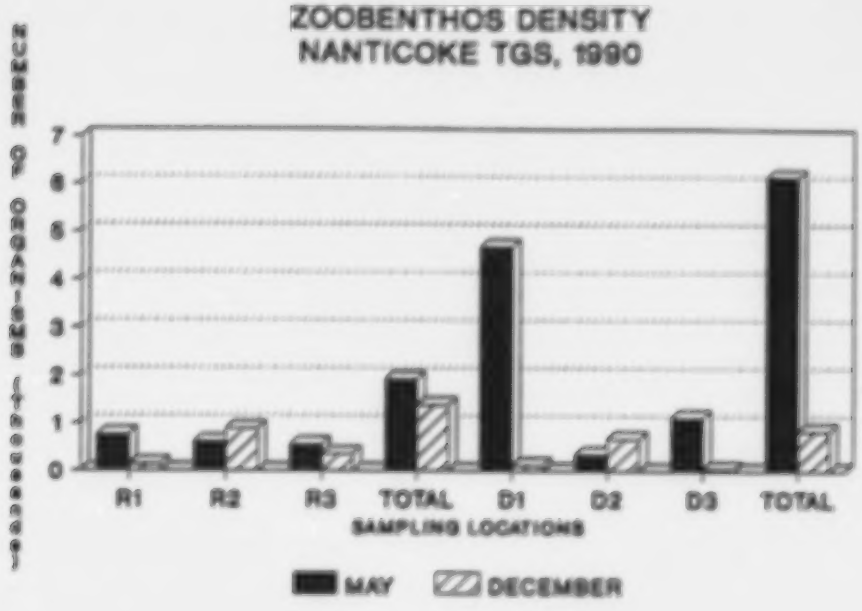


FIGURE 3.4-1

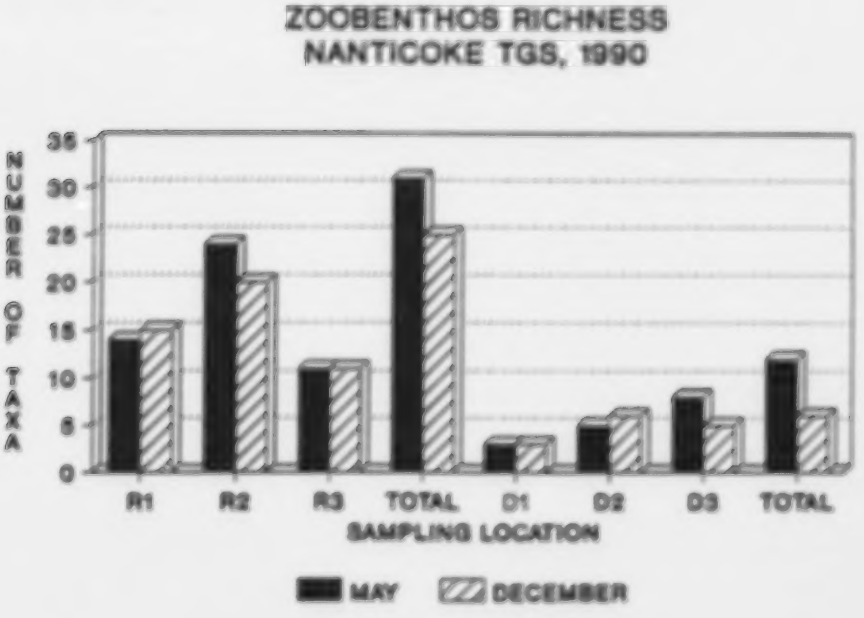


FIGURE 3.4-2

ZOOBENTHOS DENSITY BOX PLOTS. NANTICOKE TGS. 1990

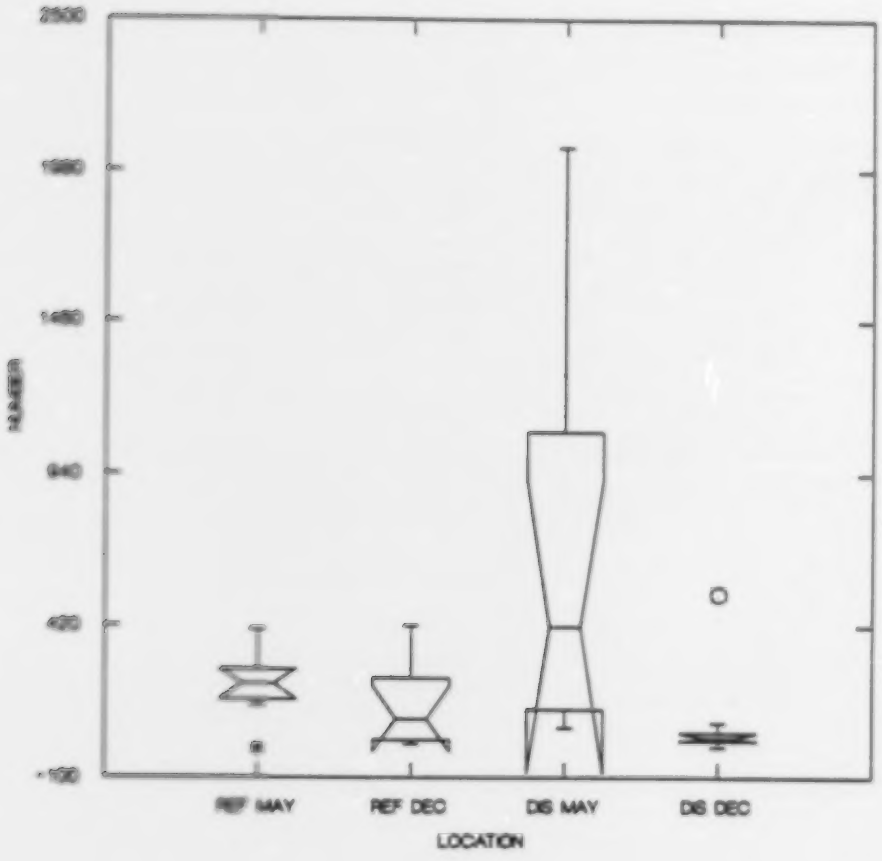


FIGURE 3.4-3

ZOOBENTHOS RICHNESS BOX PLOTS. NANTICOKE TGS. 1990

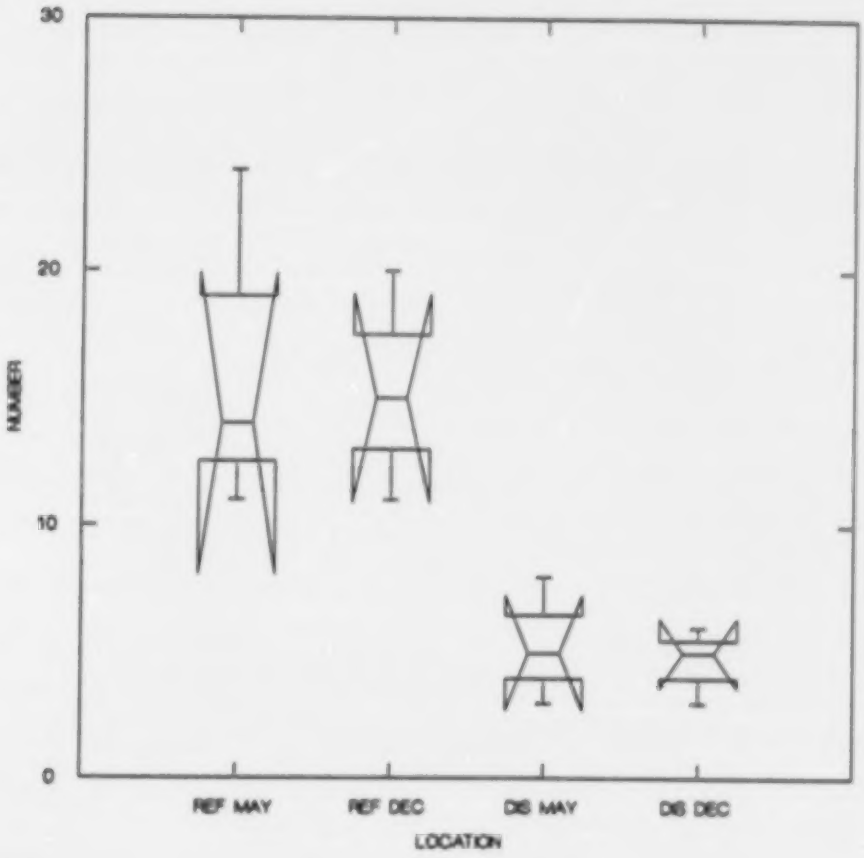


FIGURE 3.4-4

APPENDIX A

SAMPLING LOCATION DESCRIPTION

MAY

DARLINGTON MOS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
B1	10.2	11.8	9.0	COBBLE, BOULDER AND GRAVEL WITH SAND PATCHES
B2	10.5	11.2	9.0	COBBLE AND BOULDER OVER A CLAY AND SAND BOTTOM
B3	10.5	12.0	8.8	COBBLE AND BOULDER OVER HARDPACK CLAY
R1	10.0	11.0	8.0	BOULDER AND LARGE COBBLE ON SAND, SILT AND CLAY BOTTOM
R2	10.0	11.0	7.5	COBBLE AND BOULDER ON SAND AND SILT OVER HARDPACK CLAY
R3	10.3	15.0	7.5	SAME AS R2

LAKEVIEW TOS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
B1	4.0	14.9	14.9	COARSE SAND AND SILT OVER HARD CLAY, COAL PARTICLES
B2	4.0	14.9	14.9	SAME AS ABOVE
B3	4.0	14.9	14.9	SAME AS ABOVE, SCATTERED BOULDERS, STRONG DISCHARGE CURRENT
R1	7.0	13.5	9.5	UNIFORM SAND-SILT BOTTOM
R2	7.0	13.5	9.5	SAME AS R1
R3	7.0	13.5	9.5	SAME AS R1

LAMBTON TGS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
B1	5.5	14.9	13.0	COBBLE-GRAVEL-PEBBLE COVERED WITH SAND AND SILT, NO ZEBRA MUSSELS OBSERVED
B2	7.0	13.9	11.5	PEBBLE-COBBLE COVERED WITH SAND AND SILT, NO ZEBRA MUSSELS OBSERVED
B3	3.0	18.0	13.9	SAND WITH SCATTERED PEBBLES, NO ZEBRA MUSSELS VISIBLE
R1	3.0	11.0	11.0	FINE SILT, A FEW POTOMOGETON
R2	5.0	11.0	11.0	DEEP SILT
R3	7.0	11.0	11.0	PEBBLE-COBBLE COVERED WITH SAND AND SILT, NO ZEBRA MUSSELS OBSERVED

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MANITOUWADGE TGS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
B1	7.0	16.3	15.0	COBBLE AND BOULDER COVERED WITH ZEBRA MUSSELS, 15 - 20 CM ALGAE ON ALL ROCKS
B2	5.0	14.6	12.6	SAME AS ABOVE
B3	4.0	15.3	11.2	COBBLE AND SAND WITH ZEBRA MUSSELS ON ALL COBBLE
R1	5.0	13.0	12.5	OCCASIONAL COBBLE OVER HARD CLAY BOTTOM, OVERLAIN WITH 1 - 2 CM FINE SAND AND SILT, ZEBRA MUSSELS ON ALL HARD SURFACES, SHORT ALGAE
R2	6.0	12.5	11.9	COBBLE AND BOULDER COVERED WITH SILT AND SAND, ZEBRA MUSSELS ON ALL ROCKS
R3	4.3	12.5	12.5	SCATTERED COBBLE AND BOULDER COVERED WITH SAND AND SILT, 4 - 5 CM ALGAE, ZEBRA MUSSELS

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DEPTH -- METRES TEMPERATURE -- DEGREE CELSIUS

APPENDIX A

SAMPLING LOCATION DESCRIPTION

DECEMBER

DARLINGTON NGS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
D1	10.0	3.7	3.7	COBBLE AND BOULDER
D2	10.0	3.7	3.7	COBBLE AND BOULDER
D3	10.2	3.7	3.7	COBBLE AND BOULDER
R1	10.0	4.1	4.1	COBBLE AND BOULDER
R2	10.0	4.1	4.1	COBBLE AND BOULDER
R3	10.0	4.1	4.1	COBBLE AND BOULDER

LAKEVIEW TGS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
D1	4.0	9.4	9.4	ZERO VISIBILITY - ROCKY
D2	4.0	8.1	8.1	ZERO VISIBILITY - ROCKY
D3	4.5	9.0	9.0	ZERO VISIBILITY - ROCKY
R1	6.5	3.2	3.2	COBBLE, BOULDER, SAND AND SILT
R2	6.5	3.2	3.2	COBBLE, BOULDER, SAND AND SILT
R3	6.5	3.2	3.2	COBBLE, BOULDER, SAND AND SILT

LAMBTON TGS

LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
D1	4.0	16.2	16.2	SAND AND SILT WITH SOME COBBLE
D2	5.0	12.5	12.5	SAND AND SILT WITH SOME COBBLE
D3	6.0	10.1	10.1	SAND AND SILT WITH SOME COBBLE AND MACROPHYTES
R1	4.0	5.8	5.8	SILT OVER SAND
R2	5.0	5.6	5.6	SILT OVER SAND
R3	7.0	5.6	5.6	SILT OVER SAND

NANTICOKE TGS

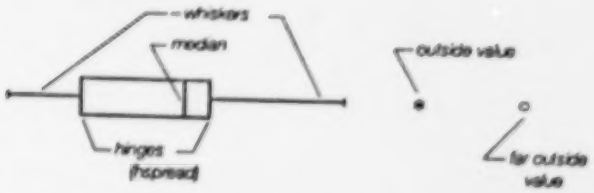
LOCATION	DEPTH	TEMPERATURE SURFACE	TEMPERATURE BOTTOM	SUBSTRATE, BOTTOM DESCRIPTION
D1	7.0	9.3	9.3	COBBLE AND GRAVEL WITH SPORADIC ATTACHED ZEBRA MUSSELS, MANY LOOSE ZEBRA MUSSELS
D2	5.0	8.7	8.7	AS ABOVE
D3	4.0	11.4	11.4	SAND, SILT AND CLAY WITH SOME COBBLE
R1	5.0	3.3	3.3	COBBLE, SILT AND SAND
R2	6.5	3.3	3.3	COBBLE WITH SOME BOULDERS AND SOME SILT
R3	4.5	3.3	3.3	BOULDERS AND SCATTERED COBBLE WITH SAND AND SILT

DEPTH -- METRES TEMPERATURE -- DEGREES CELSIUS

APPENDIX B

BOX PLOT INTERPRETATION *

The median of the batch is marked by the center vertical line. The lower and upper hinges comprise the edges of the central box. The median splits the ordered batch of numbers in half, and the hinges split the remaining halves in half again.



Definitions

To understand the remainder of the box plot, we need some definitions. *Hspread* is comparable to the interquartile range or midrange. It is the absolute value of the difference between the values of the two hinges.

The *inner fences* are defined as follows:

lower fence = lower hinge – (1.5Hspread)
upper fence = upper hinge + (1.5Hspread)

The *outer fences* are defined as follows:

lower fence = lower hinge – (3Hspread)
upper fence = upper hinge + (3Hspread)

The *whiskers* show the range of values which fall within 1.5 Hspreads of the hinges. The do *not* necessarily extend to the inner fences.

Values outside the inner fences are plotted with asterisks. Values outside the outer fences are plotted with empty circles.

* Wilkinson, Leland. SYGRAPH: The System for Graphics. Evanston, Il: SYSTAT, Inc., 1990.

McGill, R., J.W. Tukey and W.A. Larsen. 1978. Variations of Box Plots. The American Statistician, 32:12 - 16.

Notched box plots

McGill, Tukey, and Larsen (1978) implemented confidence intervals on the median of several groups in a box plot. If the intervals around two medians do not overlap, you can be confident at about the 95% level that the two population medians are different. You can do this plot in **SYGRAPH** by using the NOTCH option.

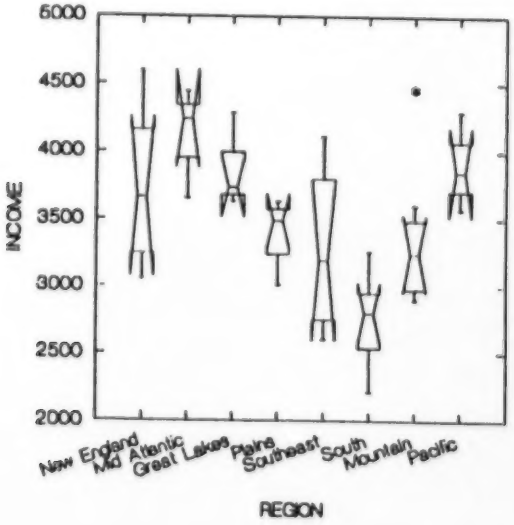
Example 8.3 shows a notched box plot of INCOME (per-capita income) by REGION for the 1970 US dataset. The boxes are notched at the median and return to full width at the lower and upper confidence interval values. Notice that some of the outer confidence limits extend beyond the hinges (the horizontal lines on either side of the narrow median line). This is unaesthetic but adheres to Tukey and McGill's original standard for the plot.

Notches are especially handy for judging differences between groups. Note, for example, that the South had a significantly lower income than New England, but not significantly lower than the Mountain states.

8.3
Notched box plot

Here is a notched plot of INCOME by REGION$.

```
BOX INCOME*REGION$ / NOTCH,NSORT
```



APPENDIX C

ZOOBENTHOS COMPOSITION
DARLINGTON, 1990

28/5/90	SAMPLE SITE																	
	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
ACARINA																		
ARRENURUS SP	1	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0	0	0
HYGROBETES SP	4	15	1	6	6	13	0	0	7	6	2	5	0	2	2	69	0	0
LEBERTIA SP	0	3	0	4	0	3	0	0	0	2	0	0	0	0	1	3	0	0
MEDIOPSIS SP	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TORRENTICOLA SP	0	0	0	1	2	7	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA																		
GAMMARUS (IMMAT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARUS FASCIATUS	4	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16
GAMMARUS PSEUDOLIMNAEUS	0	0	0	18	12	25	4	1	0	4	14	0	9	10	7	3	12	0
HYALELLA AZTECA	5	3	2	20	11	11	14	6	5	2	2	0	0	1	0	0	2	0
DECAPODA																		
CAMBARUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
CAMBARUS ROBUSTUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISOPODA																		
ASELLUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASELLUS INTERMEDIUS	6	0	31	56	11	88	16	6	5	8	24	1	10	6	17	8	19	7
DIPTERA																		
CHIRONOMIDAE																		
CHIRONOMINI SP	1	12	1	14	4	12	2	2	1	0	0	1	0	8	0	0	0	0
CHIRONOMINI (PUPA)	1	8	0	0	0	5	0	0	0	0	0	0	0	0	2	0	0	0
CHIRONOMUS THUMMI GROUP	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLADOTANYTARSUS SP	1	33	3	18	12	24	20	14	9	2	2	11	2	8	4	14	6	20
CORYNONEURA SP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DICROTENDIPES SP	4	15	2	18	9	6	6	2	1	8	12	2	5	30	11	3	5	18
HETEROTRISSOCLADIUS SP	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
MICROTENDIPES SP	7	3	4	11	5	16	5	0	1	6	4	8	0	5	9	2	0	8
MICROPSECTRA SP	0	0	0	0	0	0	0	1	0	4	0	2	2	12	3	1	1	0
NANODIAMESA SP	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ORTHOCLADIUS SP	0	9	0	0	0	1	2	1	2	2	0	0	2	2	0	1	1	0
PARAKIEFFERIELLA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2
POLYPEDILUM SP	0	9	0	0	1	0	0	0	3	0	0	0	0	0	0	1	0	1
POTTHASTIA SP	1	3	0	2	1	1	0	2	0	0	0	1	0	0	0	0	0	0
PROCLADIUS SP	0	0	0	1	1	0	0	0	1	0	0	0	0	2	0	0	0	0

PSECTROCLADIUS SP	2	0	1	0	0	3	0	1	0	2	0	0	0	0	0	0	1	0
STICTOCHIRONOMUS SP	0	6	0	1	0	0	1	0	0	0	0	1	0	2	0	0	0	0
TANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0
THIENEMANNIMYIA GROUP	5	9	4	4	12	13	6	3	0	2	6	5	0	2	6	5	7	4
MOLLUSCA																		
PELECYPODA																		
DREISSENIA POLYMORPHA	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHPAERIUM CORNEUM	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPHAERIUM TRANSVERSUM	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM COMPRESSUM	39	75	0	6	7	4	13	8	5	16	16	12	0	12	6	23	7	10
PISIDIUM HENSLOWAUUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM PUNCTATUM	36	0	0	32	20	7	14	3	0	8	4	0	10	0	0	0	0	0
PISIDIUM VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA																		
GYRAULUS PARVUS	2	0	2	0	0	0	2	2	0	2	0	0	0	4	0	0	0	0
PHYSA INTEGRA	6	6	2	5	5	9	1	0	1	0	2	0	0	2	0	0	0	0
VALVATA TRICARINATA	10	3	2	10	5	7	0	3	0	0	4	0	0	2	0	1	0	0
TRICOPTERA																		
LEPTOCERIDAE																		
CERACLEA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NYSTACIDES SP	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROTILIDAE																		
HYDROPTILA SP	5	0	3	3	8	4	0	0	0	0	2	0	0	0	0	0	0	0
OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	20	168	6	73	56	189	292	139	194	80	48	122	0	76	64	216	90	294
LIMNODRILUS HOFFMEISTERI	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
POTAMOTHRIX MOLDAVIENSIS	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
QUISTADRILUS MULTISETOSUS	0	0	0	1	0	0	0	0	0	2	4	1	0	0	2	0	1	0
SPIROSPERMA FEROI	1	0	0	0	3	0	18	6	12	4	0	1	0	1	1	0	1	2
TUBIFEX TUBIFEX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUMBRICULIDAE	2	21	2	4	3	2	8	3	0	0	0	5	0	0	0	3	4	2
NAIDIDAE																		
NAIS BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIS VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPHIDONAIS SERPENTINA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLAVINA APPENDICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIRUDINEA																		

MELOBDELLA STAGNALIS	0	0	0	6	2	6	22	3	7	0	0	0	0	4	0	2	6	10
DINA PARVA	0	0	0	0	0	0	8	2	2	0	0	0	1	0	0	0	0	0
PLACOBDELLA MONTIFERA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	187	396	72	320	200	461	454	210	258	162	148	184	43	191	135	362	164	396

DEC 18/90

SAMPLE SITE

	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
ACARINA																		
ARRENURUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROBETES SP	3	1	3	6	8	2	27	21	21	0	1	2	8	17	19	18	26	0
LEBERTIA SP	0	0	0	1	0	0	1	0	0	0	0	0	1	2	0	0	0	0
MEDIOPSIS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TORRENTICOLA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AMPHIPODA																		
GAMMARUS (IMMAT)	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0	8	0	0
GAMMARUS FASCIATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
GAMMARUS PSEUDOLIMNAEUS	3	0	1	1	4	0	6	0	0	0	1	4	3	0	15	14	12	0
HYALELLA AZTECA	4	1	3	4	6	4	65	22	6	1	0	0	2	0	2	4	3	0
DECAPODA																		
CAMBARUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAMBARUS ROBUSTUS	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
ISOPODA																		
ASELLUS SP	0	1	0	2	3	1	46	5	7	0	2	0	2	2	35	6	10	0
ASELLUS INTERMEDIUS	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0
DIPTERA																		
CHIRONOMIDAE																		
CHIRONOMINI SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMINI (PUPA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMUS (THUMMI) GROUP	1	0	0	2	11	1	0	7	2	0	0	0	0	0	2	10	0	0
CLADOTANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYNONEURA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	0	1	1	4	6	4	5	0	1	2	2	1	1	5	11	10	0	0
DICROTENDIPES SP	1	0	0	2	4	0	0	1	1	0	0	0	1	1	3	10	0	0
HETEROTRISSOCLADIUS SP	0	2	4	4	7	1	0	5	4	1	1	0	1	4	5	8	0	0
MICROTENDIPES SP	0	1	1	8	12	2	3	0	1	0	1	1	4	29	80	40	2	0
MICROPSECTRA SP	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
PARAMETRIOCNEMUS SP	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PARAMETRIOCNEMUS (PUPA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARAMETRIOCNEMUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PARAKIEFFERIELLA SP	0	10	4	12	7	7	1	3	3	3	2	1	2	9	0	12	0	0
PHAENOPSECTRA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPEDILUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POTTHASTIA SP	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PROCLADIUS SP	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PSECTROCLADIUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STICTOCHIRONOMUS SP	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0
TANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THIENEMANNIMYIA GROUP	1	0	1	3	1	0	0	0	1	0	0	0	2	1	0	0	0	0
MOLLUSCA																		
PELECYPODA																		
DREISSENIA POLYMORPHA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPHAERIUM CORNEUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPHAERIUM TRANSVERSUM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PISIDIUM SP	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
PISIDIUM COMPRESSUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM NOVELLUNUM	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM PUNCTATUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM VARIABILIS	1	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
GASTROPODA																		
BYTHINELLUS PUPOIDS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYSA INTEGRA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALVATA TRICARINATA	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TRICOPTERA																		
LEPTOCERIDAE																		
CERACLEA SP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MYSTACIDES SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROPTILIDAE																		
HYDROPTILA SP	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2	0	0
OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	0	4	7	50	93	16a	14	14a	191	7	21	5	47	172	101	13a	8b	1
LIMNODRILUS HOFFMEISTERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PSAMMORYCTIS MOLDAVIENSIS	0	0	0	0	0	0	0	0	6	3	12	0	4	8	7	4	8	0
QUISTADRILUS MULTISETOSUS	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	14	6	0
SPIROSPERMA FEROX	0	0	1	0	0	2	1	2	0	0	0	1	2	3	1	0	0	0
TUBIFEX TUBIFEX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUMBRICULIDAE	1	0	0	4	2	2	0	1	1	0	0	0	0	1	0	0	1	0
NAIDIDAE																		
NAIS BARBATA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[redacted]

[redacted]

[redacted]

SPECIES	MAY				DECEMBER			
	REFERENCE SITE TOTALS			DISCHARGE SITE TOTALS				
	1	2	3 COMBINED	1	2	3 COMBINED	1	2	3 COMBINED	1	2	3 COMBINED
[redacted]												
[redacted]	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
[redacted]	20	25	7	52	13	6	69	84	7	16	69	92	1	44	66	91
[redacted]	3	7	0	10	2	1	3	6	0	1	1	2	0	2	0	2
[redacted]	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]	0	19	0	19	0	0	0	0	0	0	0	0	0	1	0	1
[redacted]																
[redacted]	0	0	0	0	0	0	0	0	1	0	0	1	0	5	0	12
[redacted]	12	0	0	12	0	0	17	17	0	0	0	0	0	2	0	2
[redacted]	0	10	5	15	10	24	15	39	4	3	4	11	5	10	24	40
[redacted]	10	42	25	77	4	1	2	7	6	14	95	115	1	4	7	12
[redacted]																
[redacted]	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
[redacted]																
[redacted]	0	0	0	0	0	0	0	0	1	6	58	65	2	39	54	97
[redacted]	17	155	27	219	33	22	14	110	0	0	4	4	0	2	0	1
[redacted]																
[redacted]																
[redacted]	10	24	5	49	1	6	0	9	0	0	0	0	0	0	0	0
[redacted]	1	5	0	6	0	2	0	2	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	1	14	9	24	0	2	10	12
[redacted]	27	24	45	136	15	14	40	69	0	0	0	0	0	0	0	0
[redacted]	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]	21	0	0	21	0	0	0	0	2	14	6	22	5	17	10	32
[redacted]	21	21	9	61	22	46	24	94	1	0	2	3	0	0	15	15
[redacted]	0	0	1	1	0	1	0	1	0	14	9	23	2	10	0	28
[redacted]	14	12	6	32	10	14	15	41	2	22	4	28	2	121	42	165
[redacted]	0	0	1	1	0	17	2	25	0	0	0	0	1	1	0	2
[redacted]	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0
[redacted]	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
[redacted]	0	1	5	15	2	0	2	0	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	16	26	9	51	6	39	12	57
[redacted]	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0
[redacted]	0	1	3	11	0	0	2	2	0	0	0	0	0	0	0	0
[redacted]	0	0	2	10	1	0	0	1	0	2	0	2	0	4	1	5

[redacted]	0	2	1	3	0	2	0	2	0	1	0	1	0	0	0	0
[redacted]	3	3	1	7	2	0	1	3	0	0	0	0	0	0	0	0
[redacted]	0	1	1	0	1	2	0	3	0	1	2	3	0	1	0	1
[redacted]	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
[redacted]	65	29	9	56	13	0	16	27	2	4	1	7	0	3	0	13
[redacted]																
[redacted]																
[redacted]	19	19	2	33	2	2	0	4	0	0	0	0	0	0	0	0
[redacted]	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	0	2	0	2	0	1	0	1
[redacted]	110	17	26	157	44	18	80	142	0	0	0	0	1	0	0	0
[redacted]	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
[redacted]	36	59	17	112	12	10	0	22	0	0	0	0	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	2	2	0	0	0	1	0	2
[redacted]																
[redacted]																
[redacted]	4	0	4	8	2	4	0	6	0	0	0	0	0	0	0	0
[redacted]	4	0	4	8	2	4	0	6	1	0	0	1	0	0	2	2
[redacted]	15	22	3	40	4	2	1	7	1	0	0	1	0	1	0	1
[redacted]																
[redacted]																
[redacted]	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1
[redacted]	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]																
[redacted]	0	15	0	23	2	0	0	2	0	1	1	2	0	0	2	2
[redacted]																
[redacted]																
[redacted]	194	310	625	1137	250	140	600	990	19	257	311	587	33	321	223	577
LIMNODRILUS HOFFMEISTERI	1	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]	1	2	0	3	0	0	0	0	0	0	6	6	15	19	12	46
[redacted]	0	1	0	1	7	2	1	10	0	0	3	3	0	4	20	24
SPIROSPERMA FEROX	1	3	36	40	5	2	3	10	1	2	3	6	0	6	0	6
TUBIFEX TUBIFEX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[redacted]	25	9	11	45	5	0	9	14	1	0	6	15	0	1	1	2
[redacted]																
[redacted]	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
[redacted]	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
[redacted]	0	0	0	0	0	0	0	0	1	2	5	8	0	0	0	0

HIRUDINEA																		
HELOBDELLA STAGNALIS	0	14	32	46	0	4	18	22	0	3	1	4	1	5	0	6
DINA PARVA	0	0	12	12	0	1	0	1	0	0	0	0	0	0	0	0
PLACOBDELLA MONTIFERA	0	0	0	0	0	0	0	0	1	0	2	2	1	1	0	2
TOTAL SITE TAXA	22	24	30	44	29	28	25	39	21	25	27	36	13	30	21	33
TOTAL BARLINGTON TAXA	63								63							
TOTAL MONTHLY TAXA	48								41							
TOTAL ORGANISMS	659	970	926	2563	496	373	922	1791	81	425	615	1121	77	660	469	1206

APPENDIX E

ZOOBENTHOS COMPOSITION
LAKEVIEW TOS, 1990

25/05/90

SAMPLE SITE

ACARINA	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
HYDRACHNIDIA SP	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
AMPHIPODA																		
CRANGONYX PSEUDOGRACILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARUS FASCIATUS	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0
HYALELLA AZTECA	0	0	0	0	0	0	0	0	0	44	0	0	2	9	1	5	5	12
										0	0	0	0	0	0	0	0	0
ISOPODA																		
ASELLUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASELLUS INTERMEDIUS	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	1	0	3
DIPTERA																		
CHIRONOMIDAE																		
CHIRONOMI SP	0	9	8	0	2	0	1	12	20	0	0	0	0	0	0	0	0	0
CHIRONOMUS (THUMMI) GROUP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLADOTANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DICROTENDIPES SP	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0
HETEROTRISSOCLADIUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MONODIAMESA SP	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	0	0	0	0	25	0	4	0	2	3	5	0	2	3	3	0	0
PARAKIEFFERIELLA SP	0	0	0	0	0	0	0	0	0	4	3	3	4	5	5	5	2	4
PARAMETRIOCNEMUS SP	4	0	0	0	0	50	0	4	0	0	0	2	3	0	0	0	0	0
POLYPEDILUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2
PROCLADIUS SP	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PSECTROCLADIUS SP	7	9	15	6	17	50	9	8	8	4	1	2	1	3	0	7	2	4
TRICHOCLADIUS GROUP	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MOLLUSCA																		
PELECYPODA																		
DREISSENIA POLYMORPHA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPHAERIUM TRANSVERSUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM SP	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PISIDIUM COMPRESSUM	0	0	0	0	0	0	0	0	0	4	0	0	1	0	1	2	1	0
PISIDIUM PUNCTATUM	3	2	2	0	0	0	0	0	0	0	0	0	2	0	3	2	0	0
PISIDIUM VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GASTROPODA																		
PHYSA SPECIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALVATA PISCINALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
VALVATA SINCERA	0	1	0	0	1	0	0	0	0	0	0	2	0	0	0	1	0	1
OLIGOCHAETA																		
TUBIFICIDAE																		
SPECIES	109	240	176	65	112	225	174	422	1800	11	7	16	1	0	0	3	5	11
AULODRILUS MULTISETOSUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPARGANOPHILUS ESMERI	0	0	0	1	5	0	0	0	2	0	0	0	0	0	0	0	0	0
TUBIFEX TUBIFEX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LIMNODRILUS CLAPAREDIANUS	4	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
LIMNODRILUS HOFFMEISTERI	5	6	10	15	2	25	0	40	12	0	0	0	0	0	1	0	0	0
POTAMOTHRIX HELBAYSIENSIS	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUMBRICULIDAE	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
NAIDIDAE																		
NAIS BRETSCHERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIS BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIS VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRISTINA FOSCI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLAVINA APPENDICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SAMPLE SITE

Date 16-FEB

	B1A	B1B	B1C	B2A	B2B	B2C	B3A	B3B	B3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
ACARINA																		
HYDRACHNIDIA SP	4	0	0	1	0	0	2	0	4	0	0	0	0	0	0	0	0	1
AMPHIPODA																		
CRANGONYX PSEUDOGRACILIS	0	12	0	6	12	4	10	0	2	0	0	0	2	4	0	0	1	0
GAMMARUS SP	20	24	4	2	22	0	120	84	48	0	0	4	10	20	30	2	6	4
GAMMARUS FASCIATUS	36	12	0	0	6	0	10	17	40	0	0	0	2	0	30	0	4	0
HYALELLA AZTECA	0	20	0	1	10	2	0	0	0	0	0	0	0	0	0	0	0	0
ISOPODA																		
ASELLUS SP	4	12	0	7	20	2	16	21	24	2	0	0	2	0	12	0	6	0
ASELLUS INTERMEDIUS	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
DIPTERA																		

CHIRONOMIDAE																			
CHIRONOMINI SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMUS (THUMMI) GROUP	4	4	20	0	4	4	0	0	16	0	0	0	0	0	0	0	0	0	0
CLADOTANYTARSUS SP	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	0	0	0	2	2	4	0	0	4	0	0	0	0	0	0	0	0	0	0
DICROTENDIPES SP	12	0	0	2	8	2	0	0	2	0	0	0	0	0	0	0	0	2	0
HETEROTRISSOCLADIUS SP	0	0	0	2	2	2	0	0	2	0	0	0	0	0	0	0	0	0	0
MONODIAMESA SP	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARAKIEFFERIELLA SP	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPEDILUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PROCLADIUS SP	0	0	0	1	2	2	0	0	0	0	0	4	0	0	0	0	0	0	0
PSECTROCLADIUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THIENEMANNINYIA GROUP	0	0	0	1	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																			
PELECYPODA																			
DREISSENIA POLYMORPHA	0	4	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPHAERIUM TRANSVERSUM	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM SP	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM COMPRESSUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM PUNCTATUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM VARIABILIS	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA																			
PHYSA GYRINA	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
VALVATA PISCINALIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALVATA SINCERA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICOPTERA																			
HYDROPSYCHIDAE																			
HYDROPSYCHE MOROSA (GROUP)	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																			
TUBIFICIDAE																			
IMMATURE	148	460	1460	304	236	724	674	187	286	48	76	48	114	148	508	170	176	404	
BUISTADRILUS MULTISETOSUS	4	0	4	6	2	12	4	4	14	8	4	4	24	20	76	2	0	0	
SPIROSPERMA FERDI	4	4	0	2	0	2	0	2	2	2	0	0	0	0	0	2	0	0	
TUBIFEX TUBIFEX	0	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LIMNODRILUS CLAPAREDIANUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LIMNODRILUS HOFFMEISTERI	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	
POTAMOTHRIX MOLDAVIENSIS	0	0	4	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	
LUMBRICULIDAE	0	0	0	0	2	2	8	0	6	2	0	0	0	0	0	0	0	0	

| | | |

APPENDIX F

ZOOBENTHOS SITE TOTALS
LAKEVIEW, 1990

	MAY								DECEMBER							
	REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS				REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS			
SPECIES	1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED	
ACARINA																
HYDROBATES SP	2	2	0	4	0	0	2	2	4	2	6	12	0	0	1	1
AMPHIPODA																
CHAUDAYE PSEUDOGRACILIS	0	0	0	0	0	0	0	0	12	20	12	44	4	6	1	11
GAMMARUS SP	0	0	0	0	0	0	0	0	48	32	260	340	4	58	12	74
GAMMARUS FASCIATUS	3	1	0	4	44	12	22	78	28	6	75	109	0	38	4	42
HYALELLA AZTECA	0	0	0	0	0	0	0	0	28	13	0	41	0	0	0	0
ISOPODA																
ASELLUS SP	0	0	0	0	0	0	0	0	14	29	73	116	2	14	0	16
ASELLUS INTERMEDIUS	0	0	0	0	5	0	4	9	8	0	28	36	8	0	0	8
DIPTERA																
CHIRONOMIDAE																
CHIRONOMINI SP	17	2	33	52	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMUS (THUMMI) GROUP	0	0	0	0	0	0	0	0	28	8	16	52	0	0	0	0
CLADOTANYTARSUS SP	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0
CRYPTOCHIRONOMUS SP	0	0	0	0	0	0	0	0	0	8	4	12	0	0	2	2
DICROTENDIPES SP	1	1	0	2	1	2	0	3	12	12	2	26	0	0	0	0
HETEROTRISSOCLADIUS SP	0	0	0	0	0	0	0	0	0	6	2	8	0	0	0	0
MICROTENDIPES SP	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
ORTHOCLADIINAE (PUPA)	1	0	0	1	10	5	3	18	0	0	0	0	0	0	0	0
ORTHOCLADIUS SP	0	25	4	29	10	14	11	35	0	0	0	0	0	0	0	0
PARAKIEFFERIELLA SP	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0
PHAENOPSECTRA SP	4	50	4	58	2	4	4	10	0	1	0	1	0	0	0	0
POLYPEDILUM SP	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
PROCLADIUS SP	0	0	0	0	0	0	0	0	0	5	0	5	4	0	0	4
PSECTROCLADIUS SP	31	73	25	129	7	4	13	24	0	0	0	0	0	0	0	0
TRISENNAMMYIA GROUP	3	0	0	3	0	0	2	2	0	3	2	5	0	0	0	0
MOLLUSCA																
PELECYPODA																
DREISSENIA POLYMORPHA	0	0	0	0	0	0	0	0	4	3	0	7	0	0	0	0
SPHAERIUM TRANSVERSUM	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
PISIDIUM SP	0	0	0	0	13	17	3	33	0	2	0	2	0	0	0	0
PISIDIUM COMPRESSUM	0	0	0	0	8	6	37	51	0	0	0	0	0	0	0	0

PISIDIUM PUNCTATUM	7	0	0	7	0	0	1	1	0	0	0	0	0	0	0	0		
PISIDIUM VARIABILIS	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0		
GASTROPODA																		
PHYSA GYRINA	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0		
VALVATA PISCINALIS	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0		
VALVATA SINCERA	1	1	0	2	2	0	2	4	0	1	0	1	0	0	0	0		
TRICOPTERA																		
HYDROPSYCHIDAE																		
HYDROPSYCHE MOROSA (GROUP)	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0		
OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	533	402	2406	3341	34	7	19	60	2068	1264	1147	4479	172	770	750	1692		
QUISTADRILUS MULTISETOSUS	0	0	0	0	0	0	0	0	8	20	22	50	16	120	2	138		
SPIROSPERMA FEROX	0	6	2	8	0	0	1	1	8	4	4	16	2	0	2	4		
TUBIFEX TUBIFEX	0	0	0	0	0	0	0	0	8	1	0	9	0	0	0	0		
LIMNODRILUS CLAPAREDIANUS	6	0	17	23	0	0	0	0	0	0	0	0	0	0	0	0		
LIMNODRILUS HOFFMEISTERI	29	42	60	131	0	1	0	1	4	0	2	6	0	0	0	0		
POTAMOTHRIX MOLDAVIENSIS	2	0	0	2	0	0	0	0	4	4	0	8	0	0	0	0		
LUMBRICULIDAE	0	0	0	0	2	0	0	2	0	4	14	18	2	0	0	2		
NAIDIDAE																		
NAIS BRETSCHERI	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0		
NAIS BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88	88		
NAIS VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	0	2	12	10	24		
PARANAIS FRICI	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4		
SLAVINA APPENDICULATA	0	0	0	0	0	0	0	0	0	0	0	0	32	4	2	38		
TOTAL SITE TAXA	15	11	9	18	13	11	14	19	20	25	16	31	12	8	11	16		
TOTAL LAKEVIEW TAXA	44								44									
TOTAL MONTHLY TAXA	24								35									
TOTAL ORGANISMS	641	605	2555	3801	139	73	124	336	2304	1452	1667	5423	252	1022	874	2148		

APPENDIX G

ZOOBENTHOS COMPOSITION
LAMBTON, 1990

23/05/90

SAMPLE SITE

	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
AMPHIPODA																		
GAMMARUS FASCIATUS																		
DIPTERA																		
CHIRONOMIDAE																		
CLADOTANYTARSUS SP	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	10	0	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
MONODIANESA SP	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	4	2	2	2	0	0	7	7	1	2	3	1	0	0	0	3	1
ORTHOCLADIINAE (LARVAE)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARACLADOPELINA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	50	1	6	0	2	5	1	3	0	0	0	2	0	0	0	0	0	1
POLYPEDILUM SP	150	115	128	34	4	21	6	81	70	11	34	12	2	2	3	2	1	3
PROCLADIUS SP	10	1	12	0	4	1	0	12	3	1	0	0	0	0	0	2	3	1
STICTOCHIRONOMUS SP	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
THIENEMANNIMYIA GROUP	10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LEPIDOPTERA																		
PYRALIDEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																		
PELECYPODA																		
CORBICULA FLUMINEA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LAMPSILIS RADIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM SP	0	0	0	0	0	0	0	0	0	2	7	0	0	8	2	2	0	1
PISIDIUM PUNCTATUM	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA																		
AMNICOLA LIMOSA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
FERRISSIA FRAGILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYSA INTEGRA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICOPTERA																		
HYDROPSYCHIDAE																		
HYDROPSYCHE MOROSA (GROUP)	0	2	0	0	0	0	0	1	0	0	1	0	0	0	0	2	0	1
CHEUMATOPSYCHE SP	0	1	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0
BRACHYCENTRUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	130	34	76	20	10	18	60	30	13	22	44	8	22	9	17	42	6	69
LIMNODRILUS CLAPAREDIANUS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LIMNODRILUS HOFFMEISTERI	0	3	0	2	6	0	2	0	5	4	0	0	0	0	1	2	0	1
QUISTADRILUS MULTISETOSUS	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
SPIROSPERMA FERDI	10	6	10	0	0	3	3	5	11	2	0	0	5	0	0	0	0	5
POTAMOTHRIX MOLDAVIENSIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUMBRICULIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
NAIDIDAE																		
AMPHICHAETA SP	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIS BRETSCHERI	0	0	8	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
NAIS BARBATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIS VARIABILIS	0	0	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0
PARANAIS FRICI	0	0	10	0	0	3	41	14	18	0	0	0	0	0	0	0	0	14
OPHIDONAIS SERPENTINA	0	0	2	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0
SLAVINA APPENDICULATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STYLARIA LACUSTRIS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
EPHEMEROPTERA																		
CAENIS SP	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HEPTAGENIA SP	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
HEXAGENIA SP	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Dec 03/90

SAMPLE SITE

	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
AMPHIPODA																		
GAMMARUS FASCIATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	5
DIPTERA																		
CHIRONOMIDAE																		
CLADOTANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	4	0	8	16	0	4	10	8	6	0	0	0	0	0	2	0	0	0
MONODIAMESA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (LARVAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARACLADOPELINA SP	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	0	0	36	56	28	4	22	30	4	0	0	4	4	0	2	0	0	0
POLYPEDILUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
PROCLADIUS SP	2	0	8	8	0	4	10	4	4	0	0	0	0	0	0	0	0	0

STICTOCHIRONOMUS SP	0	0	52	44	0	28	110	28	46	0	0	0	0	0	0	0	0	0	0
TANYTARSUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THIENEMANNIMYIA GROUP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOPTERA																			
PYRALIDEA	0	0	0	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0	
MOLLUSCA																			
PELECYPODA																			
CORBICULA FLUMINEA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	
LAMPSILIS RADIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
PISIDIUM SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PISIDIUM PUNCTATUM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
GASTROPODA																			
AMNICOLA LIMOSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FERRISSIA FRAGILIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
PHYSA INTEGRA	0	0	0	4	0	0	2	0	0	0	0	0	0	0	0	1	0	0	
TRICOPTERA																			
HYDROPSYCHIDAE																			
HYDROPSYCHE MOROSA (GROUP)	2	0	0	8	0	0	0	0	0	0	0	0	0	12	0	1	0	2	
CHEUMATOPSYCHE SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
BRACHYCENTRUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
OLIGOCHAETA																			
TUBIFICIDAE																			
IMMATURE	126	86	196	192	204	252	42	88	106	104	364	84	332	176	526	4	12	7	
LIMNODRILUS CLAPAREDIANUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LIMNODRILES HOFFMEISTERI	0	0	8	0	8	0	0	4	4	0	0	0	4	12	0	0	0	0	
QUISTADRILUS MULTISETOSUS	2	5	8	8	0	10	2	2	0	4	0	0	0	0	4	0	0	0	
SPIROSPERMA FEROX	2	2	0	4	0	0	8	8	4	0	0	0	0	12	2	1	0	1	
POTAMOTHRIX MOLDAVIENSIS	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	
LUMBRICULIDAE																			
NAIDIDAE																			
AMPHICHAETA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NAIS BRETSCHERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NAIS BARBATA	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NAIS VARIABLIS	0	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PARANAIS FRICI	0	0	0	4	0	0	4	17	8	0	0	0	0	0	0	0	0	4	
OPHIDONAIS SERPENTINA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SLAVINA APPENDICULATA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
STYLARIA LACUSTRIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EPHEMEROPTERA																			

CARNIS SP
NEPTUNEOLA SP
NEUSOLEOLA SP

APPENDIX H
ZOOBENTHOS SITE TOTALS
LAMBTON TOE, 1990

	MAY								DECEMBER							
	REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS				REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS			
SPECIES	1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED	
AMPHIPODA																
GAMMARUS FASCIATUS	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
DIPTERA																
CHIRONOMIDAE																
CLADOTANYTARSUS SP	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	12	1	0	12	0	1	1	2	12	29	29	36	0	2	0	2
MICROTENDIPES SP	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPA)	6	4	19	29	6	1	4	11	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (LARVAE)	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
PARACLADOPELMA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	57	7	4	68	2	0	1	5	1	6	0	1	0	0	0	0
POLYPEDILUM SP	345	59	137	609	57	7	6	70	36	88	56	180	0	6	0	10
PROCLADIUS SP	33	5	15	65	1	0	6	7	0	0	0	0	0	6	0	6
STICTOCHIRONOMUS SP	0	0	0	0	1	0	0	1	10	17	10	40	0	0	0	0
TANYTARSUS SP	0	1	0	0	1	0	0	1	52	72	104	208	0	0	0	0
THIENEMANNIMYIA GROUP	10	0	0	10	0	1	0	1	0	0	0	0	0	0	0	0
LEPIDOPTERA																
PYRALIDAE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																
PELECYPODA																
CORBICULA FLUMINEA	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0	2
LAMPSILIS RADIATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
PISIDIUM SP	0	0	0	0	9	13	1	22	0	0	0	0	0	0	0	0
PISIDIUM PUNCTATUM	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA																
AMNICOLA LIMOSA	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
FERRISSIA PARALLELA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
PHYSA GYRINA	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1
TRICOPTERA																
HYDROPSYCHIDAE																
HYDROPSYCHE BIDENTATA GROUP	2	0	1	3	1	0	3	4	2	0	0	10	0	12	3	15

CHEUMATOPSYCHE SP	1	0	3	0	0	3	0	3	0	0	0	0	0	0	0	1	1	
BRACHYCENTRUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	203	48	103	291	79	48	117	239	648	648	216	1292	332	1128	23	1609		
LIMNODRILUS CLAPAREDIANUS	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0		
LIMNODRILUS HOFFMEISTERI	3	0	7	10	0	1	2	0	0	0	0	24	0	16	0	16		
QUISTADRILUS MULTISETOSUS	0	1	0	5	0	0	1	1	15	10	6	37	0	0	0	0		
SPIROSPERMA FEROX	25	3	19	48	2	5	5	12	0	0	22	38	0	16	2	18		
POTAMOTHRIX MOLDAVIENSIS	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0		
LUMBRICULIDAE	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0		
NAIDIDAE																		
AMPHICHAETA SP	29	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0		
NAIS BRETSCHERI	0	0	3	11	0	0	0	0	0	0	0	0	0	0	0	0		
NAIS BARBATA	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0		
NAIS VARIABILIS	0	0	3	3	0	0	0	0	2	4	0	6	0	0	0	0		
PARANAIS FREI	10	2	11	86	0	0	14	14	0	0	29	33	0	0	0	0		
SPHAERANAIS SUSPECTUS	2	2	2	0	0	0	0	0	1	0	0	1	0	0	0	0		
SLAVINA APPENDICULATA	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0		
STYLARIA LACUSTRIS	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0		
EPHEMEROPTERA																		
CAENIS SP	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0		
HEPTAGENIA SP	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0		
HEXAGENIA SP	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0		
TOTAL SITE TAXA	14	12	16	20	14	9	13	21	14	13	11	18	3	11	19	17		
TOTAL LAWSON TAXA	42								42									
TOTAL KENTALY TAXA	32								23									
TOTAL ORGANISMS	839	142	410	1301	161	78	145	449	554	894	585	2512	340	1162	44	1750		

APPENDIX I

BENTHIC COMPOSITION
MANITOBA TOR, 1991

	SAMPLE SITE																	
ORGANISM																		
LUMBRICULIDA SP	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA																		
[illegible] SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARUS FASCIATUS	2	11	0	9	1	0	5	0	20	61	29	84	20	15	18	10	24	11
HYALELLA AZTECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIPTERA																		
CHIRONOMIDAE																		
CHIRONOMINI SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMINI (PUPA)	0	0	0	0	3	0	0	0	0	0	0	4	0	0	0	0	0	0
CLADOTANYTARSUS SP	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOTENDIPES SP	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
DICROTENDIPES SP	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
HETEROTRISSOCLADIUS SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MICROPSECTRA SP	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
MICROTENDIPES SP	0	0	0	0	14	9	0	0	0	0	0	0	0	0	0	0	0	0
PARACLADOPELMA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARATENDIPES SP	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PE[illegible]TILUM SP	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
POTTHASTIA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
PROCLADIUS SP	4	2	3	1	7	6	1	0	3	0	6	3	0	0	0	0	0	0
PSECTROCLADIUS SP	2	2	1	3	2	1	3	0	2	0	0	0	0	0	0	0	7	1
PSEUDOCHIRONOMUS SP	0	0	0	0	31	37	0	0	0	0	0	2	0	0	0	0	0	0
STICTOCHIRONOMUS SP	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
TANYTARSUS SP	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
MOLLUSCA																		
PELECYPODA																		
DREISSENIA POLYMORPHA	152	157	276	153	94	197	200	0	67	2000	1500	1000	111	56	127	81	257	600
SPHAERIUM SIRILE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
SPHAERIUM TRANSVERSUM	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM VARIABILIS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
VELOSA IRIS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
GASTROPODA																		
PHYSA [illegible]	0	0	0	1	0	3	0	0	1	0	0	0	0	0	0	0	0	0

PHYSA INTEGRA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM PARVUS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNICOLA LIMOSA	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNICOLA WALKERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARSTONIA DECEPTA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
GONOBASIS LIVESCENS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
TRICOPTERA																			
LEPTOCERIDAE																			
MYSTACIDES SP	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
HYDROPTILIDAE																			
HYDROPTILA SP	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCENTROPIDIDAE																			
POLYCENTROPUS CINEREUS	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																			
TUBIFICIDAE																			
IMMATURE	0	1	0	0	0	4	2	0	3	0	0	0	1	0	0	2	13	0	
AULODRILUS MULTISETOSUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SPIROSPERMA FEROX	66	44	26	0	0	0	106	0	69	0	0	0	0	0	0	0	30	0	
POTAMOTHRIX HOLSATICUS	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	4	0	
LUMBRICULIDAE	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
NAIDIDAE																			
NAIS BRETSCHERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
HIRUDINEA																			
HELOBDELLA STAGNALIS	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
EPHEMEROPTERA																			
EPHEMERELLA SP	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	

Dec 19/90

SAMPLE SITE

	R1A	R1B	R1C	R2A	R2B	R2C	R3A	R3B	R3C	D1A	D1B	D1C	D2A	D2B	D2C	D3A	D3B	D3C
ACARINA																		
LEBERTIA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA																		

APPENDIX J

ZOOBENTHOS SITE TOTALS
HANTICOKE TGS, 1990

	MAY								DECEMBER							
	REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS				REFERENCE SITE TOTALS				DISCHARGE SITE TOTALS			
SPECIES	1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED		1	2	3 COMBINED	
ACARINA																
LEBERTIA SP	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA																
GAMMARUS SP	0	0	0	0	0	0	0	0	42	2	5	49	57	210	10	285
GAMMARUS FASCIATUS	13	10	25	48	184	53	45	282	16	158	0	174	50	345	4	419
HYALELLA AZTECA	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
DIPTERA																
CHIRONOMIDAE																
CHIRONOMINI SP	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	0
CHIRONOMINI (PUPA)	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0
CLADOTANYTARSUS SP	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOCHIRONOMUS SP	0	3	0	3	0	0	0	0	1	43	14	58	0	0	0	0
CRYPTOTENDIPES SP	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
DICROTENDIPES SP	1	2	0	3	0	0	0	0	0	5	0	5	0	0	0	0
HETEROTRISSOCLADIUS SP	0	0	0	0	0	0	0	0	2	0	0	2	0	4	0	4
MICROPSECTRA SP	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0
MICROTENDIPES SP	0	21	0	21	0	0	0	0	1	19	0	20	0	0	0	0
PARAKIEFFERIELLA SP	0	0	0	0	0	0	0	0	3	11	0	14	0	0	0	0
PARATENDIPES SP	1	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0
PHAENOPSECTRA SP	0	0	0	0	0	0	0	0	0	7	0	7	0	0	0	0
POLYPEDILUM SP	0	2	1	3	0	0	1	1	0	2	0	2	0	0	0	0
POTTHASTIA SP	0	0	0	0	0	0	0	0	1	6	0	7	0	0	0	0
PROCLADIUS SP	9	14	4	27	0	0	8	8	4	67	26	97	0	3	3	6
PSECTROCLADIUS SP	5	6	5	16	0	0	0	0	0	0	0	0	0	0	0	0
PSEUDOCHIRONOMUS SP	0	60	0	60	0	0	0	0	2	25	2	29	0	0	0	0
STICTOCHIRONOMUS SP	0	4	0	4	0	0	0	0	0	10	0	10	0	0	0	0
TANYTARSUS SP	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																
PELECYPODA																
DREISSENIA POLYMORPHA	585	444	355	1384	4500	294	1038	5832	45	162	1	208	14	78	26	118
SPHAERIUM SIMILE	0	0	0	0	0	0	1	1	0	2	0	2	0	0	0	0
SPHAERIUM TRANSVERSUM	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PISIDIUM VARIABILIS	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0
VILOSA IRIS	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

GASTROPODA																		
PHYSA GYRINA	0	4	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYSA INTEGRA	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0
GYRAULUS PARVUS	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMNICOLA LIMOSA	2	2	0	4	0	0	0	0	2	0	0	2	0	0	0	0	0	0
AMNICOLA WALKERI	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MARSTONIA DECEPTA	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
GONIOBASIS LIVESCENS	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICOPTERA																		
LEPTOCERIDAE																		
MYSTACIDES SP	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROTILIDAE																		
HYDROPTILA SP	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCENTROPODIDAE																		
POLYCENTROPUS CINEREUS	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLIGOCHAETA																		
TUBIFICIDAE																		
IMMATURE	1	4	5	10	0	1	15	16	17	297	299	613	0	7	3	10		
QUISTADRILUS MULTISETOSUS	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0		
SPIROSPERMA FEROX	136	0	155	291	0	0	4	4	0	54	0	54	0	0	0	0		
POTAMOTHRIX MOLDAVIENSIS	0	8	0	8	0	0	0	0	0	0	4	4	0	0	0	0		
LUMBRICULIDAE	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0		
NAIDIDAE																		
NAIS BRETSCHERI	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0		
HIRUDINEA																		
HELOBDELLA STAGNALIS	2	0	0	2	0	0	1	1	1	4	1	6	0	0	0	0		
EPHEMEROPTERA																		
EPHEMERELLA SP	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0		
TOTAL SITE TAXA	14	20	11	31	3	5	8	12	15	20	11	25	3	6	5	6		
TOTAL HANTICOKE TAXA	46								46									
TOTAL MONTHLY TAXA	35								25									
TOTAL ORGANISMS	759	609	555	1923	4687	351	1123	6161	139	887	358	1384	121	675	46	842		